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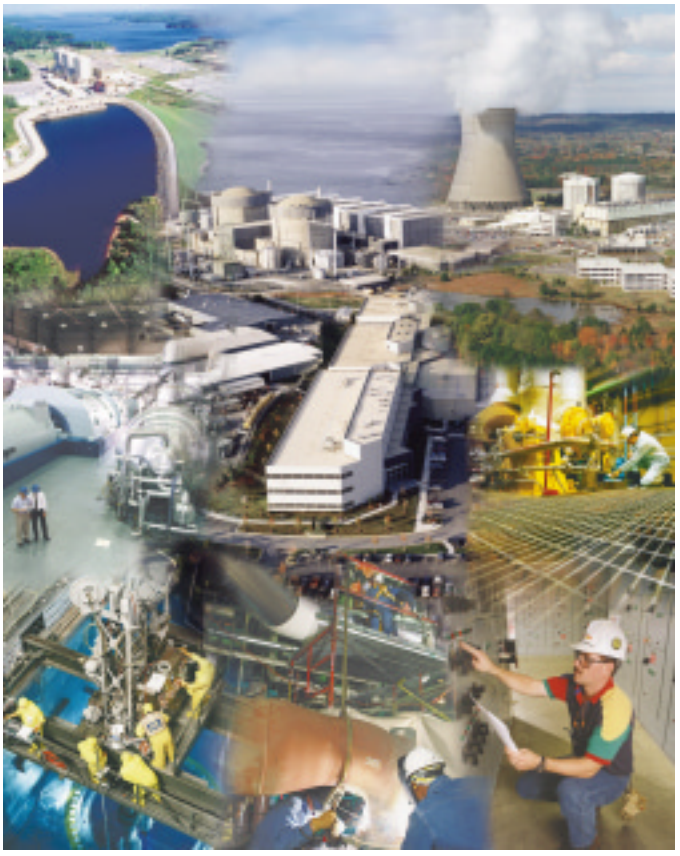
FALL 2000



About EPRI®

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute® in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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EPRI JOURNAL®

Staff and Contributors

DAVID DIETRICH, *Editor-in-Chief*
TAYLOR MOORE, *Senior Feature Writer*
SUSAN DOLDER, *Senior Technical Editor*
MARTHA LOVETTE, *Senior Production Editor*
DEBRA MANEGOLD, *Typographer*
KATHY MARTY, *Art Consultant*

BRENT BARKER, *Manager, Corporate Communications*
MARK GABRIEL, *Director, Global Marketing*

Address correspondence to:
Editor-in-Chief
EPRI Journal
P.O. Box 10412
Palo Alto, CA 94303

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For further information about EPRI, call the EPRI Customer Assistance Center at 800-313-3774 or 650-855-2121 and press 4, or e-mail askepri@epri.com.

COVER: With license renewal processes and procedures firmly established by the successful Calvert Cliffs and Oconee applications, industry leaders expect most U.S. nuclear plants to eventually seek 20-year license renewal. (Photo collage by Martha Lovette)

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Editorial

Preserving the Nuclear Option for Energy Security

Regulatory approval of the first renewed operating licenses for U.S. nuclear power plants has set the stage for a new era—one that ensures a continuing role for nuclear energy in preserving America's energy security and resource diversity. This new era is a direct result of the electric utility industry's collaboration with EPRI over the past 20 years to establish the technical foundation for extended plant operation and to incorporate life-cycle management methodology into ongoing plant operations and maintenance. The pioneering efforts of Constellation Energy's Calvert Cliffs plant and Duke Energy's Oconee plant, whose license renewal applications were approved by the Nuclear Regulatory Commission earlier this year, benefit the entire nuclear utility sector. These efforts have also established reasonable costs and schedules for renewal applications.

The successful launch of the nuclear plant license renewal era clearly demonstrates the strategic value of long-term R&D and highlights the importance of continued collaboration in the technical work required to support extended plant operation over the next 30 to 40 years. EPRI initiated its license renewal work with its nuclear utility members more than 20 years ago to help ensure that this strategic option would be available when needed. As it turns out, the renewal option has arrived in time to impact utility decision making in the emerging deregulated, competitive electricity supply market.

License renewal provides ample time to address the inevitable challenges for a commercial revival of nuclear power as a strategically vital, economical, emissions- and carbon-free energy source in the United States. Nuclear plants have generated almost 25% of the nation's electricity through the first half of 2000. Nevertheless, in the eyes of the public, there are open questions. For example, the management of used fuel is an issue of public concern. Nuclear plants have stored used fuel safely on-site since the beginning of the nuclear era, but we need to push ahead with the federal fuel repository for long-term storage. Here again R&D has helped resolve the technical questions.

Paralleling efforts to develop a spent-fuel repository must be a major new initiative by utilities, reactor vendors, and the government to reduce the capital cost of future nuclear plants. Cost reductions beyond those already made will be necessary if new nuclear capacity is to be competitive with natural gas–fired combined-cycle plants on the basis of current fuel prices. The optimization of currently licensed passive and evolutionary advanced light water reactor designs offers one approach, and—when proven viable—smaller, modular nuclear plants using high-temperature gas as a coolant will offer another.

Many countries that have committed to reductions in carbon dioxide emissions from fossil fuel combustion will face enormous economic penalties if the nuclear alternative is eliminated. The same may be true for the United States if we do not fund the engineering development required for a true renaissance of nuclear power. A sustainable national energy future requires solutions that meet our growing energy needs in a way that is safe, reliable, and environmentally friendly. Nuclear energy has all these attributes. It does not pollute the air or water. Its fuel supply is plentiful, inexpensive, and secure. Nuclear energy helps preserve scarce natural resources.

The American public increasingly recognizes the importance of nuclear energy as part of our future energy strategy. In order to maintain and enhance public support, the nuclear industry must continue to operate the current reactor fleet safely and reliably and to invest in technology advances. A robust national energy policy and responsible stewardship of natural resources require that we keep all our energy options open.

Ted Marston
Vice President and
Chief Nuclear Officer

Contributors

License Renewal Revitalizes the Nuclear Industry (page 8) was written by Taylor Moore, *Journal* senior feature writer, with assistance from John Carey of EPRI's Science and Technology Development Division.

JOHN CAREY, manager for life-cycle management and license renewal, heads a research program aimed at obtaining maximum value from existing nuclear

power plants. Since the early 1980s, the team he leads has focused on establishing a viable, predictable, and cost-effective plant license renewal process; developing aging management tools; and developing and applying nuclear asset management tools for plant valuation and resource allocation decisions. Before coming to EPRI in 1976, Carey was an associate mechanical engineer at Argonne National Laboratory. He received BS, MS, and PhD degrees in engineering mechanics from the Illinois Institute of Technology.

Retail Service Offerings: Thinking Beyond Price (page 18) was written by David C. Lineweber and Patricia B. Garber of Primen, an EPRI affiliate focused on developing and providing comprehensive energy market intelligence.

DAVID C. LINEWEBER, vice president in charge of Primen's Knowledge Development Group, directs research that supports strategic business decision mak-

ing by providing insights about the likely customer value of changes in retail business direction. Before joining Primen, which began operation this year, Lineweber was a vice president at PHB Hagler Bailly and at National Analysts; at both firms he was responsible for developing and directing energy-related marketing and marketing research practices. Before 1990, he was a vice president at Cambridge Reports/Research International and an assistant professor of sociology at Gonzaga University. Lineweber earned a BA degree in sociology from the University of Delaware and MA and PhD degrees in the same field from Stanford University.

PATRICIA B. GARBER is a principal with the Knowledge Development Group at Primen, specializing in customer choice, retail marketing strategy,

customer loyalty, market segmentation, and new products. Before joining Primen, she served as manager of retail energy products at EPRI and as a senior consultant at Hagler Bailly. Earlier in her career, she was a senior consultant at J.D. Power and Associates and a product director at the University of Wisconsin. Garber holds three degrees in sociology—a BA from California State University and an MA and a PhD from the University of California at Los Angeles.

Powering Healthcare's Future (page 24) was written by science writer David Boutacoff, with assistance from Winston Chow and Keith Carns of EPRI's Science and Technology Development Division.

WINSTON CHOW is manager of the industrial, agricultural, residential, and commercial technology and services research area. Earlier he was product line

manager for environmental research and program manager for waste and water management and pollution prevention. Before joining EPRI in 1979, he spent seven years as a power plant design engineering supervisor at Bechtel. Before that, he worked for Raychem on polymer R&D. Chow holds a BS from the University of California at Berkeley and an MS from San Jose State University, both in chemical engineering, and an MBA from San Francisco State University.

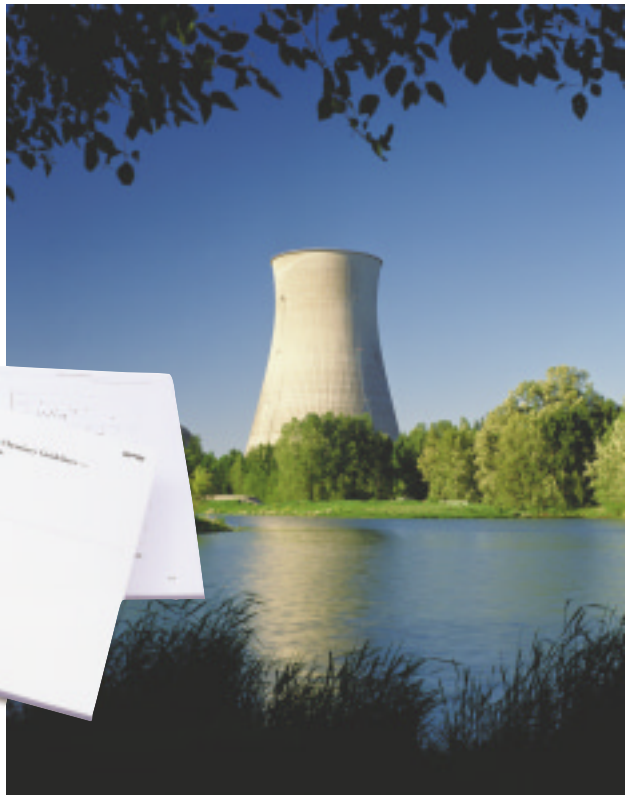
KEITH CARNS is manager of the municipal water/wastewater technology target, the food and agriculture technology target, and the EPRI Healthcare Initiative.

Before joining EPRI in 1993, he ran an environmental consulting firm for two years. His earlier experience includes 24 years with the East Bay Municipal Utility District of Oakland, California. Carns has a BS in civil engineering and an MS in environmental engineering from the University of California at Berkeley.

Products

Deliverables now available to EPRI members and customers

BWR Water Chemistry Guidelines—2000 Revision



The control of BWR water chemistry increases plant availability by reducing intergranular stress corrosion cracking (IGSCC) in cooling-system piping and reactor internals. The latest revision of the *BWR Water Chemistry Guidelines* presents new information that plant chemistry personnel can use to develop proactive, plant-specific water chemistry programs to minimize IGSCC, flow-accelerated corrosion, fuel performance degradation, and radiation buildup. Two EPRI research advisory committees revised the guidelines in response to the discovery of IGSCC in the core shrouds of several BWRs—a finding that suggests cracking may be present in other reactor internal components as well. The recommendations for adjusting chemistry limits and implementing more cost-effective monitoring are expected to improve protection against materials and fuel problems and reduce the risk of losing reactor output because of chemistry transients.

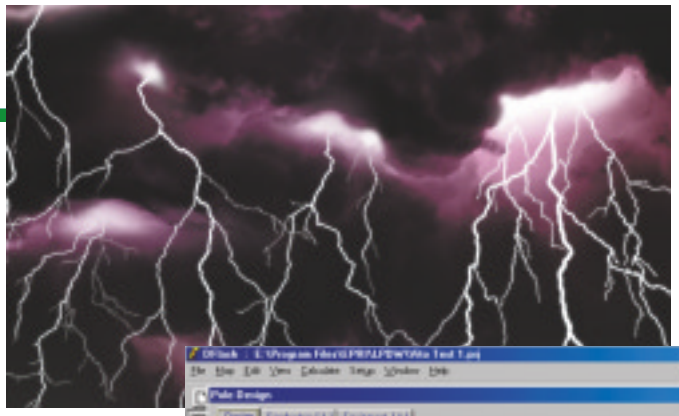
■ *For more information, contact Chris Wood, cwood@epri.com, 650-855-2379. To order the guidelines (TR-103515-R2), call EPRI Customer Service, 800-313-3774.*

Decontamination Handbook

Decontamination has played a key role in reducing occupational exposures to radiation at U.S. nuclear power plants over the past decade. In this process, dilute chemical solvents are used to remove deposited radioactivity. EPRI has been at the forefront of developing decontamination solvents and helping utilities implement plant demonstrations. Today's challenges are to reduce the costs of decontamination activities and to minimize the activities' impact on the duration of plant outages. The *Decontamination Handbook* compiles lessons learned from sub- and full-system applications, as well as decontamination after permanent plant shutdown. It covers dilute solvents, corrosion issues, the effects of coolant chemistry, recontamination rates, and waste disposal issues. The handbook synthesizes critical information to help utility personnel plan quick, efficient decontamination activities that meet plant-specific needs.

■ *For more information, contact Howard Ocken, hocken@epri.com, 650-855-2055. To order the handbook (TR-112352), call EPRI Customer Service, 800-313-3774.*

Lightning Protection Design Workstation 5.0



EPRI's Lightning Protection Design Workstation™ is a state-of-the-art tool to help engineers design lightning protection for transmission and distribution lines, using such techniques as shielding, improved grounding, line arresters, and upgraded insulation. LPDW incorporates accepted methods and standards from EPRI, IEEE, and international sources. It can use data from the National Lightning Detection Network, and it integrates the results of research involving lightning stroke characteristics, composite insulation, and lightning surge characteristics. A new module in version 5.0 includes an underground cable design worksheet and calculator. Designed for the Windows 98 and NT operating systems, LPDW includes reference material and an on-line help system.

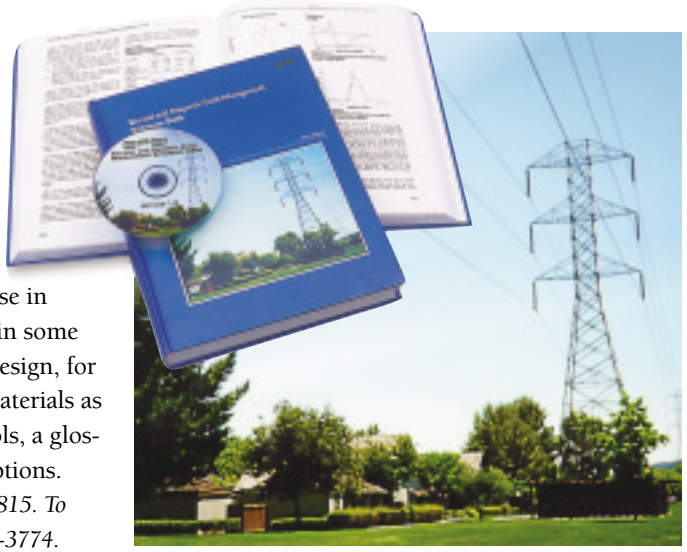
■ *For more information, contact Vito Longo, vlongo@epri.com, 650-855-8586, or David Robbins, drobbins@epri.com, 413-499-5711. To order the software (AP-113176), call EPRI Customer Service, 800-313-3774.*

Electricity Pricing Book

Pricing in today's rapidly changing industry is the focus of a new book edited by Ahmad Faruqui, EPRI's area manager for retail and power markets, and Kelly Eakin, vice president of the energy consulting firm Christensen Associates. The book, entitled *Pricing in Competitive Electricity Markets,* introduces new pricing concepts, methodologies, models, tools, and databases for dealing with issues—such as the loss of assets—arising in the evolution from traditional ratemaking under regulation to a restructured, deregulated market. Case studies in restructuring, risk management, and the pricing of energy services are analyzed by a variety of experts. Among the topics covered are market design and price behavior, the anticipation of competitor responses, and the effect of technology on pricing.

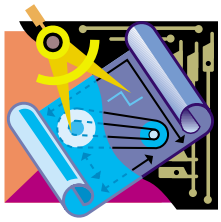
■ *For more information, contact Ahmad Faruqui, afaruqui@epri.com, 650-855-2096. To order the book ($129.95), call Kluwer Academic Publishers, 781-871-6600, or e-mail kluwer@wkap.com.*

EMF Management Reference Book



Research by EPRI and other organizations over the past 20 years has provided much practical information about the management of electric and magnetic fields near power delivery facilities. The results of this research have been consolidated in a useful reference book for professionals involved in the engineering aspects of EMF management. The new guide presents a large number of options for use in reducing power-frequency fields—options that have been tested and, in some cases, actually demonstrated on utility systems. In the area of shield design, for example, the guide discusses new knowledge about the use of such materials as copper and sheet steel. An accompanying CD contains calculation tools, a glossary, and tutorial material to help the user apply the field reduction options.

■ *For more information, contact Frank Young, fyoung@epri.com, 650-855-2815. To order the reference book (AP-114200), call EPRI Customer Service, 800-313-3774.*

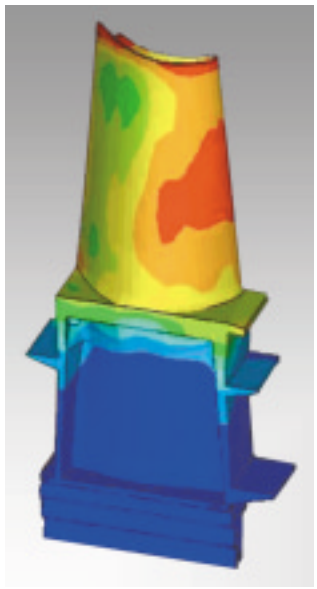


Project Startups

New ventures of importance to power and service providers

Pinpointing Hot Spots in Combustion Turbine Blades

Some 75% of all new generating capacity planned in the United States over the next decade is expected to be based on combustion turbines. As the use of these turbines increases, plant operators are becoming acutely aware of the machines' higher-than-projected operating and maintenance expenses. In particular, there is increasing concern about the replacement and other costs related to the durability and performance of hot-section parts, which experience the greatest thermal stress. A growing backlog of orders for the latest combustion turbine models is adding to unit availability and maintenance pressures.



In 1998, operators of advanced F-class combustion turbines reported that none of the first-row blades in machines recently placed in operation had lasted the expected 24,000 hours before refurbishment. Although the severity and nature of the problems varied, they involved machines from all major vendors. Concerns over commissioning delays, spiraling O&M costs, and failures of advanced turbines have persisted into 2000.

"Striking parallels can be drawn between the present combustion turbine boom and the introduction of a new generation of steam turbines in the 1970s," says Vis Viswanathan, an EPRI technical fellow and senior manager for materials applications technology. "At that time, an unprecedented increase in the number of steam turbine units created an insatiable demand for replacement parts to ensure unit availability to meet consumer electricity demand. The demand for replacement parts was exacerbated by infant mortality problems when reliable turbine models were scaled up beyond their design-cycle capabilities and the knowledge base of field service personnel." The costs and lost availability for power production associated with the steam turbine boom were documented in an EPRI survey at the time.

In the current combustion turbine boom, EPRI's goal is to reduce the life-cycle costs of hot-section components by at least one-third. This amounts to over $45 million for a single unit in either base-load or cycling duty. A two-year EPRI initiative on the life management of hot-section components—aimed at providing the engineering knowledge needed by operators of advanced F-class machines to retain effective control over replacement of the most expensive parts—has produced a number of key results at its midpoint. These include a hot-section life management system for predicting creep and fatigue damage. This system can predict the location of thermal barrier coating failure in first-row buckets, which are the most complex to analyze in terms of temperature and stress. Combining aerothermal and structural analyses with damage algorithms, the system accurately predicts blade temperature and stress distributions for both steady-state and transient conditions.

The initial sponsors of the hot-section components initiative chose the General Electric Frame 7FA+ and Frame 9FA turbines as the prototype cases for validating the system's first-row bucket prediction and simulation capabilities. A six-step validation process included the use of airflow tests, optical pyrometry measurements of surface temperatures, and metallographic analysis.

The analytical approach embodied in EPRI's life management platform for hot-section parts offers companies a vendor-independent source of technical expertise. "We have the combination of capabilities necessary for bringing the elements of materials, design, and operation together," says John Scheibel, EPRI's area manager for combustion turbines. "Through advanced simulations, the life management platform provides the temperature and stress information required to determine the life consumption of any operating cycle. It's a design tool for combustion turbine operators, who can benchmark their specific operating scenarios against the generic properties of the turbine manufacturer's design."

Another product of the initiative is the COATLIFE code for estimating the remaining life of thermal barrier coatings. A comprehensive handbook on the properties of all bucket materials is expected to be available by the end of this year, and guidelines for improved buckets and for reducing life-cycle costs will also be issued beginning around then.

Companies that operate combustion turbines and are concerned about escalating parts costs and related durability issues are encouraged to join the EPRI hot-section component life management program. Potential future work includes the development of the hot-section life management system and COATLIFE into continuous, on-line monitoring tools. The life management approach could also be extended to other bucket rows and nozzles in 7FA machines and to other F-class turbine models.

■ *For more information, contact John Scheibel, jscheibe@epri.com, 650-855-2850, or Vis Viswanathan, rviswana@epri.com, 650-855-2450.*

New Push for Sustainable Coal Power

As noted in EPRI's Electricity Technology Roadmap, population growth and efforts to raise the standard of living for billions of impoverished people are forecast to create a greater than fourfold increase in worldwide electricity demand by 2050. Meeting this projected demand will require the equivalent of building a new 1000-MW power plant somewhere in the world every two days for 50 years. Even with a dramatically greater use of renewable energy sources in the future, coal—the world's most abundant fossil fuel—will continue to play a large role in meeting the ever-growing demand for electricity in this century. This is particularly true for developing countries like China and India that have large, indigenous coal reserves.

To accelerate research on generating electricity from coal in ways that are more environmentally sustainable, EPRI has launched the Global Coal Initiative, a series of major new technology development efforts for which broad-based support is being solicited among the power generation, coal mining, and coal transportation industries. The new initiative currently includes six programs aimed at mobilizing technology advances for coal-fired plants that would have virtually no air pollutant by-products and negligible or no net emissions of carbon dioxide, the chief greenhouse gas implicated in global warming. The programs address CO_2 control options; ultrasupercritical pulverized-coal plants; advanced high-efficiency plants based on integrated gasification–combined-cycle configurations and pressurized and atmospheric fluidized-bed combustion configurations; plants fueled by low-volatile coal; lignite-fueled plants; and real-options market analyses.

"It is imperative that we burn coal more cleanly and efficiently, with minimal CO_2 emissions, to avoid the risk of global climate change," says Stephen Gehl, EPRI's director of strategic technology and alliances. "The Global Coal Initiative will spearhead research on methods for keeping CO_2 out of the atmosphere by sequestering it in natural sinks or exhausted oil fields."

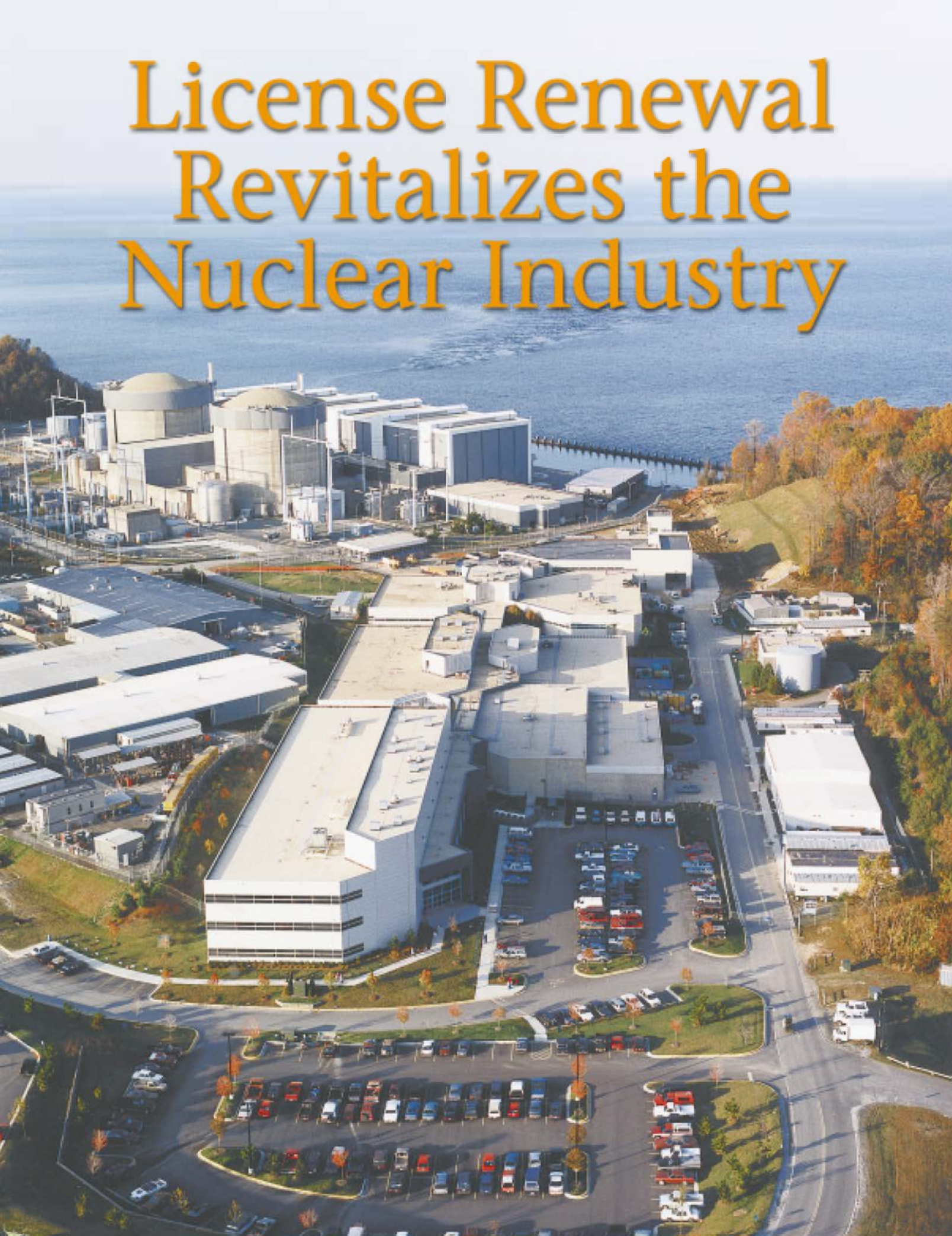
Like the EPRI Electricity Technology Roadmap, the Global Coal Initiative is being developed in dialogue with interested stakeholders worldwide: power producers, coal companies, railroads, equipment vendors, banks, government agencies, and research foundations. Early participants have an opportunity to help shape the content of the initiative and to begin to receive products and services as soon as the end of this year.

Southern Company, one of the country's largest electric utilities, has joined the initiative under a program that is developing real-options business models to help power producers evaluate technology investments in a deregulated market with fluctuating fuel and electricity prices. "EPRI's Global Coal Initiative recognizes that the future begins today, and it offers practical strategies to keep coal a competitive performer in the changing energy marketplace," says Randall Rush, director of Southern Company's Power Systems Development Facility, an R&D center in Wilsonville, Alabama, that EPRI has long cosponsored.

In the 1980s, EPRI led an international collaboration of generating companies and equipment suppliers in a broad effort to advance pulverized-coal technologies. The widely recognized initiative led to new materials and designs that shattered then-existing engineering barriers to higher operating temperatures and pressures for the more efficient burning of coal. "On the basis of stunning new advances in materials and design concepts, we are ready to move ahead with the next phase of this work," says EPRI's Tony Armor, technical executive and generation market segment director. "In combined-cycle operation, ultrasupercritical pulverized-coal plants are capable of achieving well over 50% efficiency, far exceeding current plant performance levels."

■ *For more information, visit the EPRI Destinations Web site, www.epri.com/destinations/index.asp, and search for Global Coal Initiative, or contact Tony Armor, aarmor@epri.com, 650-855-2961, or Stu Dalton, sdalton@epri.com, 650-855-2467.*

License Renewal Revitalizes the Nuclear Industry



The Story in Brief

The operating licenses of approximately 10% of current U.S. nuclear reactors are scheduled to expire by the end of 2010, an eventuality once seen as the beginning of the end for the nuclear option in the United States. But well-maintained nuclear power plants have demonstrated their capability for safe, reliable operation well beyond their initial 40-year license term—a period based on amortization accounting rather than inherent operational limitations. This year, more than two decades of preparatory engineering and planning by nuclear utilities and EPRI have paid off in the NRC's approval of 20-year license renewals for two nuclear plants, effectively extending nuclear's franchise for power production well into the new century. About one-third of the country's 103 nuclear reactors plan to apply for renewal by 2003, and most currently operating plants are expected to renew their licenses. With capital costs for the plants largely paid for, the revitalized nuclear fleet will be among the most competitive power generators available.

A REMARKABLE MILESTONE has been reached by the once-quiescent nuclear power sector of the U.S. electric utility industry with the recent regulatory approval of two plants for an additional 20 years of operation beyond their original 40-year license terms. The successful completion of the license renewal process by these pressurized water reactor (PWR) plants, together with the establishment of the technical and regulatory bases for their approval and extended operation, represents the realization of a key long-standing goal of EPRI's nuclear power program. That goal is to ensure that the 103 units of the U.S. reactor fleet remain dependable, profitable electricity generators well into the new century.

The U.S. Nuclear Regulatory Commission approved renewed licenses for Constellation Energy Group's two-unit, 1700-MW Calvert Cliffs plant in Maryland last March and for Duke Energy Corporation's three-unit, 2500-MW Oconee plant in South Carolina two months later. The commission's actions were widely applauded.

"It was with intense pride that I received . . . the nation's first renewed operating licenses for a nuclear power plant," Constellation Chairman and CEO Christian Poindexter told company shareholders last April. "The additional 20 years of authorized operation will take us to the mid-2030s. The material condition of the plant will soon be enhanced by a steam generator replacement project. And the expertise we have in managing the aging process . . . will contribute to a solid base of generation for our merchant energy business." Formerly operated by Constellation's Baltimore Gas and Electric subsidiary, Calvert Cliffs is now part of Constellation Nuclear Services, a nonregulated generating subsidiary.

Commenting on Oconee's renewed licenses, Michael Tuckman, executive vice president for nuclear generation at Duke Energy, said, "Twenty years of additional life for this station will serve our region very well." He noted that Duke's extensive inspection, maintenance, and equipment replacement programs gave the utility confidence that "the station will operate safely and reliably well into the twenty-first century."

Joe Colvin, president and chief executive officer of the Nuclear Energy Institute (NEI), the industry's Washington-based policy organization, sees the recent renewal activity as a key enabler of a secure energy future. "The process for renewing licenses at nuclear power plants ensures a continued, reliable, clean supply of electricity to satisfy the increasing demands of the digital economy," says Colvin. "There will be many more license renewals at other nuclear

by Taylor Moore

COURTESY CONSTELLATION ENERGY GROUP

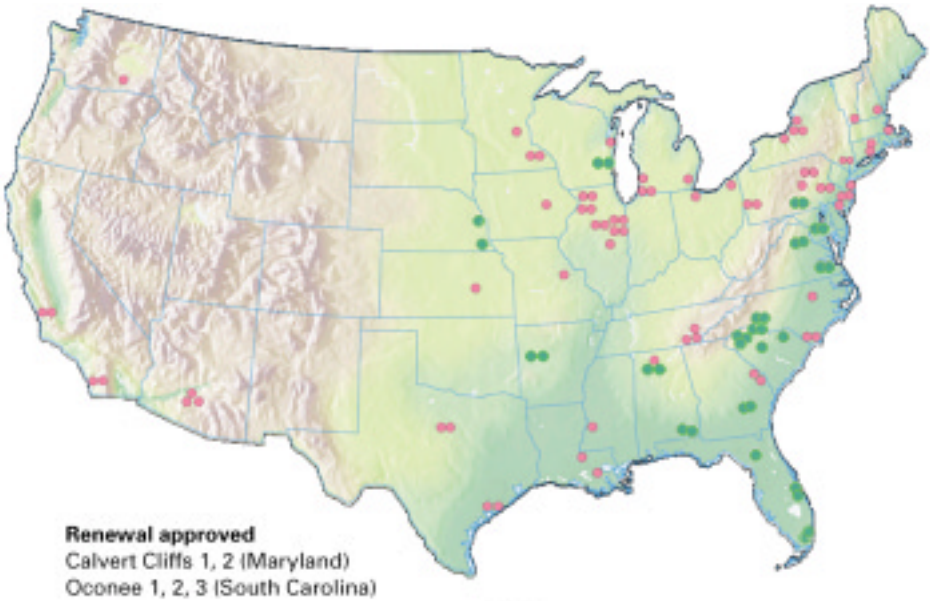
plants, further demonstrating the viability of nuclear energy and its vital role in America's energy mix."

Indeed, license renewal applications have already been submitted to the NRC by Entergy Corporation for the Arkansas Nuclear One unit 1 (ANO-1) PWR and by Southern Nuclear for the two units of its Hatch plant in Georgia, the first boiling water reactors (BWRs) to apply. NEI says that the owners of about one-third of the country's nuclear reactors intend to apply for license renewal by 2003, and ultimately most plants are expected to renew their licenses.

"The NRC's in-depth review, which closely examines the safety and environmental record of these facilities, provides a clearly marked path for other electricity companies pursuing license renewal," says Colvin. "Clearly, the next chapter in our nation's nuclear energy history is being written, and it is full of promise." EPRI and the U.S. Department of Energy estimated in the late 1980s that the value of 20 more years of operation at all units could be as much as $200 billion; more recent estimates by NEI range from $110 billion to $180 billion. U.S. nuclear plants represent a combined 103 GW of installed generating capacity (about 15% of total capacity) and supply one-fifth of the country's electricity.

Laying the groundwork

The success of the Calvert Cliffs and Oconee applications is both the start of the era of license renewal and the culmination of two decades of utility industry efforts. These efforts laid the technical and regulatory groundwork and defined the engineering needed for extended operations under plant life-cycle management. Life-cycle programs focus on managing the aging of critical plant structures, systems, and components.



Renewal approved
Calvert Cliffs 1, 2 (Maryland)
Oconee 1, 2, 3 (South Carolina)

Application filed
Arkansas Nuclear One unit 1
Hatch 1, 2 (Georgia)

2000
Turkey Point 3, 4 (Florida)

2001
Catawba 1, 2 (South Carolina)
McGuire 1, 2 (North Carolina)
Peach Bottom 2, 3 (Pennsylvania)
North Anna 1, 2 (Virginia)
Surry 1, 2 (Virginia)

2002
Fort Calhoun 1 (Nebraska)
St. Lucie 1, 2 (Florida)
Point Beach 1, 2 (Wisconsin)
Summer (South Carolina)
Crystal River 3 (Florida)

2003
Farley 1, 2 (Alabama)
Arkansas Nuclear One unit 2
Robinson 2 (South Carolina)
Browns Ferry 2, 3 (Alabama)
Cooper (Nebraska)

Nuclear utilities have expressed the intention to seek license renewal for about a third (green dots) of the country's 103 power reactors by 2003. A renewal application can be submitted for a unit after 20 years of service up until 5 years before its current license expires.

In coordination with other industry organizations, EPRI played a key technical support role for nuclear plant operators throughout the evolution of NRC rules governing license renewal. EPRI took the lead in developing a knowledge base on the effects of aging on various materials and plant systems. The results were presented in a series of industry reports that were submitted to the NRC and that are extensively referenced by utilities in license renewal applications.

"From the beginning, EPRI has been an invaluable partner and a vital technical resource in life-cycle management," says Duke's Tuckman. "EPRI's early leadership set the stage for the technical work that has evolved into license renewal. Its technical expertise has helped resolve issues and answer the hard questions that confronted the NRC and our industry. This collaborative work has been essential in the success of the first two applicants for license renewal."

Pilot life extension studies conducted by EPRI for two other plants in the early 1980s demonstrated the economic and technical feasibility of extended operation (see sidebar, p. 16). Subsequently, EPRI's ongoing nuclear R&D program generated vital data on the aging of various safety-related nuclear plant materials as new questions about age-related degradation mechanisms—such as various forms of corrosion—arose. And much of the engineering work for the Calvert Cliffs and Oconee license renewal applications was made available to other utilities as EPRI technical reports. EPRI has provided this sustained support of its nuclear clients over the past two decades for a modest cumulative investment of some $22 million, supplemented by $15 million in member cofunding.

"Even if the total amount spent by EPRI and the lead utility license renewal applicants for each reactor vendor design reaches $100 million in the course of making license renewal happen, the money will have been astoundingly well spent," says Barth Doroshuk, president and chief operating officer of Constellation Nuclear Services and the former manager for license renewal at Calvert Cliffs. "The payback on

In March, Constellation Energy's twin-unit, 1700-MW Calvert Cliffs plant on Chesapeake Bay in Maryland became the first U.S. nuclear plant to receive 20-year license renewals from the NRC. Units 1 and 2 are now cleared to operate until 2034 and 2036, respectively. Constellation Chairman and CEO Christian Poindexter joined the Calvert Cliffs staff in celebrating the successful pioneering of the renewal process.

PHOTOS COURTESY CONSTELLATION ENERGY GROUP

the investment is almost immeasurable, considering the positive impact it will have for the entire industry."

The reason, Doroshuk explains, is that nuclear license renewal has arrived in the nick of time to be a factor in critical utility decision making. The decisions will address how best to manage generating assets during industry restructuring and consolidation and the emergence of deregulated, competitive wholesale—and eventually retail—electricity markets. Until only recently, uncertainties about NRC requirements for license renewal, together with uncertainties about how past utility investments in nuclear plants would be treated by state regulatory commissions during the transition to deregulated markets, had many companies questioning their continued involvement in nuclear generation. They were considering plant closures and decommissioning or sale. Indeed, several plants changed ownership in recent years—with the first few selling at bargain-basement prices—and several others have been shut down for decommissioning.

"The industry's successful demonstration of the license renewal option has brought new life into an industry that, as little as five years ago, appeared headed toward increased plant closures," says John Carey, EPRI manager for life-cycle management. "The outlook has changed dramatically."

Catalyzing a resurgence

Ted Marston, EPRI's chief nuclear officer, calls the change "a revitalization of industry psychology" and attributes it to several factors. "For one, the issue of stranded costs has been resolved, at least in those states where deregulation and restructuring have already occurred. State commissions have put negotiated charges on consumers' electric bills, spread over a number of years, for recovering nuclear plant capital investments.

"Meanwhile, the NRC has revised and clarified the license renewal rules, making that option more economical and practical for utilities to consider; now the regulatory process overall is less prescriptive and based more on safety performance. In addition, utilities that continued to invest in maintaining their nuclear plants are finding that the plants really are in very good shape. Continuing consolidation among the nuclear utilities promises to further reduce operating and maintenance costs. Achieving even greater efficiencies in operations and in equipment and service purchases is critical to the success of nuclear power in the deregulated marketplace."

Thanks to greater regulatory certainty and to lower O&M costs, the better-managed, better-performing nuclear units with little or no remaining debt are very economical generators. They are some of the cheapest, potentially most lucrative assets available at a time when the country's electricity generating base is restructuring for retail price competition. (It is also a time when, with very few new baseload power plants of any type being built, capacity reserve margins are shrinking to dangerously low levels in some regions.) Citing production cost data from McGraw-Hill's Utility Data Institute, NEI says 43 U.S. reactors generate electricity for less than 2¢ per kilowatthour. The average production cost of U.S. nuclear plants is within one-tenth of one cent per kilowatthour of that of coal-fired plants, the cheapest source of baseload generation.

Operating in deregulated, competitive markets gives nuclear plants the opportunity to profit most when spot market electricity prices are highest—typically during periods of hot summer weather when the

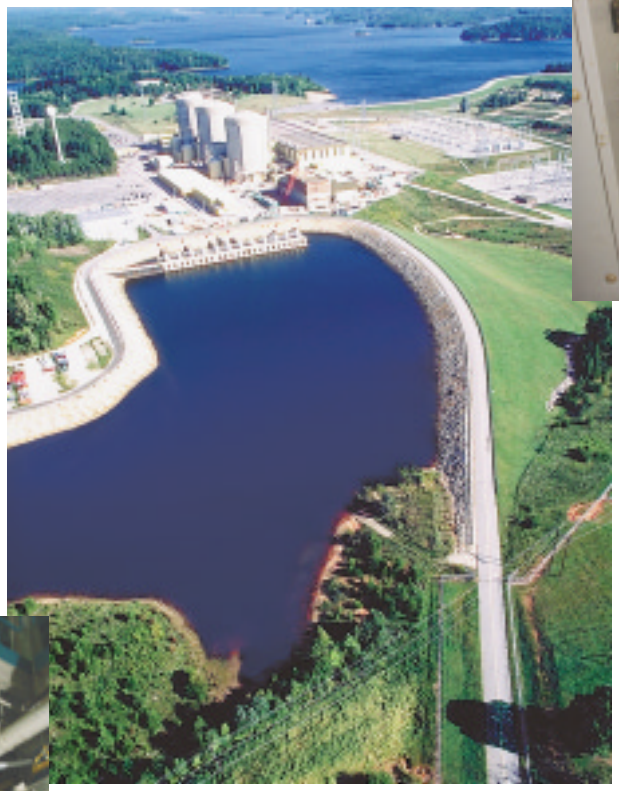
electricity demand for air conditioning is high.

Several industry initiatives have contributed to the performance turnaround of nuclear plants. For example, better planning and management of refueling outages have cut their median duration from 75.5 days in 1990 to 39 days in 1999; the top-performing units refuel within 25 days. The less time a plant is down for refueling, the greater its productivity. In 1998, 89 nuclear units had capacity factors above 70%, and 74 of these had capacity factors above 80%. The respective numbers in 1990 were 56 and 31 units.

"Deregulation may turn out to be the best thing to happen to nuclear generation in the United States," says Marston. "Utilities with well-run nuclear plants are keenly aware of the value of these plants in a competitive market."

U.S. nuclear plants also have substantial environmental value, producing virtually no emissions. According to NEI, an equivalent amount of capacity fueled by coal, oil, or natural gas would release some 133 million tons of carbon dioxide a year. DOE has acknowledged the importance of nuclear license renewal in helping the country limit the growth of carbon emissions from fossil fuel use. It says that a typical nuclear plant displaces about 1.2 million metric tons of carbon-equivalent greenhouse gases each year of operation.

The NRC approved Duke Energy's license renewal application for its three-unit, 2500-MW Oconee plant on Lake Keowee in Seneca, South Carolina, in May. In planning for license renewal at Oconee, the company adopted a comprehensive life-cycle management approach focused not only on extending operation from 40 to 60 years but also on benefiting operations for the remainder of the plant's original license term.



PHOTOS COURTESY DUKE ENERGY CORP.

Compared with any alternative for new or repowered fossil generating capacity, obtaining a nuclear plant license renewal has a low direct cost, and that cost is expected to get even lower. Constellation Energy says its 2500-page Calvert Cliffs renewal application, which took nearly a decade of planning and preparation, cost around $19 million, or $11 per kilowatt. Duke Energy says the cost of preparing the application for its larger Oconee plant was about $12 million, or $4.73 per kilowatt. As a result of standardization, future applications beyond the first few of a specific reactor design are expected to cost much less.

But the cost of preparing a license renewal application is only part of the calculus. "License renewal is just the regulatory ticket to operate the plant for an additional 20 years," notes John Carey. "It certainly gives a utility flexibility in strategic planning, but profitable operation of the plant will depend on its life-cycle management program. How do you run the plant to get the highest production? When is the best time to refurbish or replace components? How do you avoid failures at the lowest cost? How do you find suppliers for replacement parts? These are all part of life-cycle management, which EPRI has been working on in tandem with license renewal."

As part of plant life-cycle management, additional capital investments may be needed to ensure economical operation over the extended license term, including replacement of large components or upgrading of key systems. For example, Constellation Energy and Duke Energy plan to replace all the steam generators over the next several years at Calvert Cliffs and Oconee at a cost of over $300 million for each plant. In addition, both companies are planning to spend a similar sum for other equipment and system upgrades at the plants over the next five to seven years.

"These plants are not unlike any large manufacturing facility when it comes to making capital investments to ensure their reliable and safe operation," says Doroshuk of Constellation Nuclear. "As long as a plant can continue to produce electricity and investments can be made to keep it safe, reliable, and in compliance with regulatory requirements, plant upgrades make sense. We're not unlike other industries

that compete on the basis of cost-effective operation of facilities. The Calvert Cliffs and Oconee renewals and planned upgrades illustrate how license renewal and plant life management go hand in hand."

With only a few years left on an operating license, utilities would be reluctant to make substantial investments like the $300 million Constellation and Duke are each planning to spend for new steam generators. But that amount is only a fraction of the projected value of Calvert Cliffs or Oconee over an extended operating life. Says Carey, "License renewal effectively minimizes the endgame effect of declining investment in a plant as it ages."

Looking ahead with a new lease on life

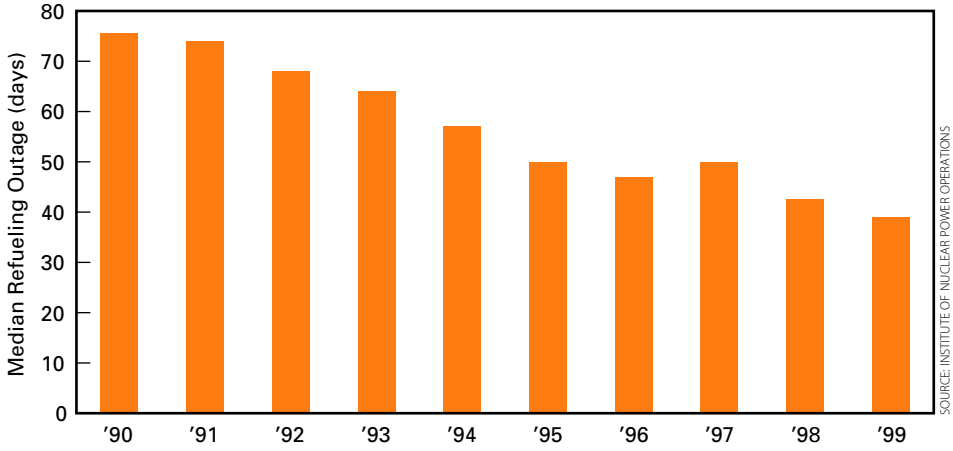
By the end of this decade, it is expected that all the plants planning to apply for license renewal will have done so and that the NRC will have reviewed and ruled on each individual unit. Beyond that point comes the real work of life-cycle management for each plant.

According to Greg Robison, Duke Energy project manager for license renewal, planning for Oconee's license renewal was a strong motivator for taking a larger, life-cycle management, perspective. "We began to think long ago about critical components in the plant—the pressure vessel and key piping and pumps. Over time we realized that life-cycle management is multifaceted and not just about pieces of hardware. We had to remind ourselves to back up and ask broader, longer-term questions: How much are we spending on maintenance? What kinds of things are going to develop as the plant gets older? What kinds of modernization are going to be needed? When you do that, you go beyond safety and reliability issues. That's where life-cycle management comes in—looking at the total plant to understand technically how it ages and to understand what it's going to take financially to stay in business."

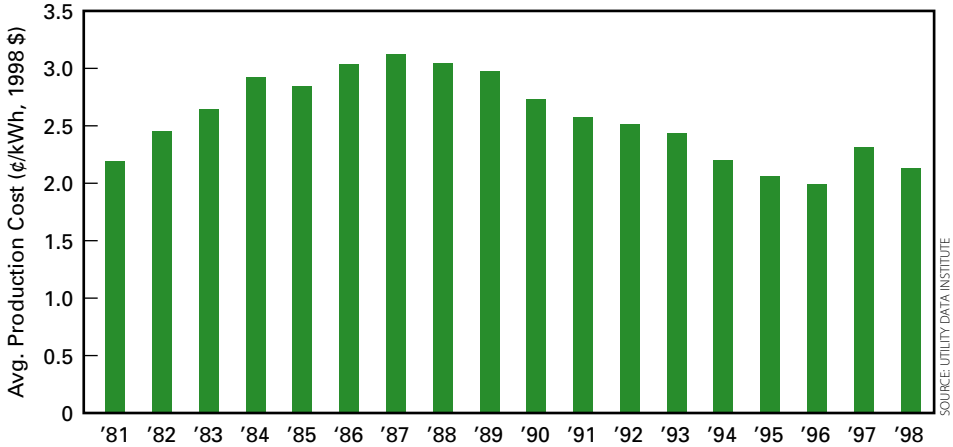
Looking five years out, says Robison, "we see deregulation coming, and we see a continued need for the electric utility industry to be able to manage the aging of plant hardware and to be able to afford plant retrofits, control systems upgrades, and the like. Because the U.S. nuclear plant fleet is not standardized, we need continual dialogue to come up with solutions that work for each plant. EPRI provides a forum for having those dialogues, and we try to take advantage of them as often as we can."

For Duke, every lesson learned from the experience of relicensing Oconee is a lesson that can be applied several times again. The company is already working on license renewal applications for its McGuire and Catawba plants. "We expect many cost elements to be less for McGuire and Catawba—certainly the technical development costs should be less. We've already published a lot of work, much of which we can reuse, and EPRI has published a lot. When we began work on the Oconee application, we had plant-specific problems. Now we have industry solutions that can be applied," says Robison.

"The industry and the NRC are in the process of standardizing what we've learned from the Calvert Cliffs and Oconee work," Robison continues. "In considering the aging of a piece of hardware, we know it's a product of the materials, the environment the hardware is exposed to, and the loads or stresses applied to it. That's generally true regardless of the industry involved. Through its publications, EPRI has helped us put into perspective the fact that the



Nuclear utilities have had great success in reducing the time that units are out of service for refueling, with better outage planning and management cutting the median duration of refueling outages from 75.5 days in 1990 to 39 days in 1999. This marked improvement has been largely responsible for a steady increase in U.S. nuclear plant capacity factors in recent years—to an average 85.5% in 1999.



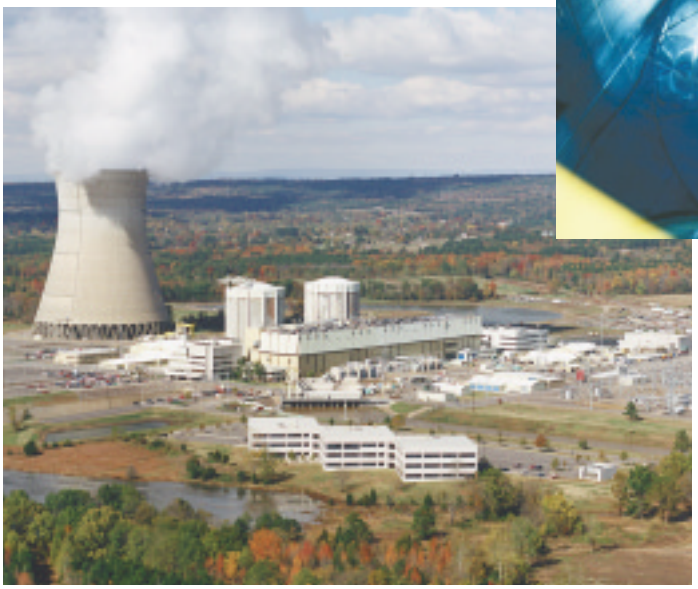
In contrast to the 1980s, when increased regulatory requirements drove up nuclear O&M costs substantially, the 1990s produced a clear decline in average production costs, thanks in part to more-efficient refueling and lower forced-outage rates. The best-performing nuclear plants today generate electricity for less than 2¢ per kilowatthour, and the average production cost for all nuclear plants is within a fraction of a cent of that for coal-fired plants.

process is going to occur in every nuclear plant.

"We need to look at how we manage a particular kind of aging and find a common approach for doing it—like the EPRI water chemistry guidelines we all use. In that case, EPRI's work helped to standardize a plant programmatic solution that prevents corrosion problems in piping systems. We expect there will be other such areas where commonality can be derived from an EPRI effort—for example, the area of flow-accelerated corrosion."

Entergy submitted a license renewal application for unit 1 of its Arkansas Nuclear One plant in Russellville in February 2000, and it has informed the NRC of its intent to apply for ANO unit 2 in 2003 and for all its other nuclear plants between 2003 and 2010. These actions are in line with a growth strategy the company announced in 1998 that is based on power generation—especially on the global development of merchant power plants and on nuclear power operations and management.

PHOTOS BY PAUL NEHRENZ, COURTESY ENTERGY CORP.



Returns on R&D investment

The willingness of nuclear utilities to support EPRI's collaborative program has paid dividends over the near term—dividends that are expected to be critically important for extended operation.

"EPRI has developed many programs that have to be credited for contributing to our license renewal application," says Chuck Pierce, license renewal project manager at Southern Nuclear, which has submitted a renewal application for its Hatch BWR units to the NRC. "Without those programs having been generically fleshed out by EPRI, we would be having a much more difficult time right now with license renewal. EPRI's BWRVIP [BWR Vessel and Internals Project] and the BWR water chemistry guidelines are particularly important. We will need those programs well into the future to continue to mitigate aging, particularly as new issues arise." (Earlier this year, the NRC approved two BWRVIP guideline reports for referencing in license renewal applications.)

On the basis of EPRI's work demonstrating the benefits of life-cycle management programs, Southern Nuclear is considering implementing its own program at Hatch. EPRI recently published Southern's time-limited aging analysis for the Hatch plant to benefit other BWR utilities considering license renewal.

Preserving and updating the historical body of technical knowledge about aging effects constitute an important role for EPRI, which has the expertise to evaluate new information and developments. An example of this role cited by Pierce and by Garry Young, license renewal project manager for Entergy's ANO-1, is the recent licensing of a series of mechanical and structural analytical tools developed by the Babcock & Wilcox Owners Group. EPRI will maintain these tools and expand them with information on other vendor designs.

Says Young, "From my point of view, having these tools available through EPRI gives us the added benefit of input from the entire industry; everyone's experience will be incorporated, making the tools more complete and useful to a wider variety of plants. The analytical tools represent a key product. When they were B&W's, we used them in preparing our renewal application for ANO-1, and we expect to rely on them in future license renewal projects—for ANO-2 and all the other Entergy nuclear plants." Entergy Operations, an Entergy subsidiary, operates five nuclear units in the company's four-state service area—the two ANO units, Grand Gulf in Mississippi, and River Bend and Waterford 3 in Louisiana. Another subsidiary, Entergy Nuclear, acquired the Pilgrim plant in Massachusetts and, more recently, the Indian Point 3 and Fitzpatrick units from the New York Power Authority.

Entergy submitted its license renewal application for ANO-1 in January 2000 and is now fielding queries from the NRC staff. Consistent with the experience at Calvert Cliffs and Oconee, Entergy anticipates NRC approval by January 2002. The same team that prepared the ANO-1 renewal application will begin working around mid-2001 on the application for ANO-2, which has a different vendor design than ANO-1. Entergy hopes to submit the ANO-2 application around the third quarter of 2003.

"As the NRC reviews the ANO-1 application, we're being asked about things like environmentally assisted fatigue in reactor cooling system piping, an aging mechanism that is still a focus of research," says Young. "That's the kind of very technical issue EPRI is helping the industry deal with. Since we don't have an expert on that subject in our company, we expect to depend on EPRI to help us evaluate the research data as it becomes available."

A market for renewal services

Virtually right out of the gate from the Calvert Cliffs and Oconee extended license approvals, the successful applicants launched commercial ventures to market their license renewal experience and expertise to other utilities.

Both Constellation Nuclear Services and a joint venture of Duke Engineering & Services (an independent affiliate of Duke Energy) and Scientech (a nuclear and industrial services firm) are marketing themselves as seasoned veterans of the rigorous license renewal process. Both offer full-scope project planning and execution, from initial plant strategy and decision analysis to the completion of the renewal process, as well as other strategic engineering services. Entergy Nuclear is another entrant in the field, having partnered with Framatome Technologies to offer license renewal services and engineering to U.S. plants. Other companies also offer license renewal and life-cycle management services to nuclear utilities.

"These kinds of ventures indicate how rapidly license renewal has matured into a commercial reality," says EPRI's Carey. The DE&S-Scientech team says it contributed to each of the four renewal applications submitted to the NRC so far and is working with five other license renewal projects that expect to submit applications over the next two years. And Doroshuk of Constellation Nuclear reports that his company is working at almost every U.S. nuclear utility site pursuing license renewal, as well as at nuclear plants in Korea and Japan.

The engineering consulting services of these ventures will complement, rather than compete with, EPRI's core R&D work, says Doroshuk. "We encourage our clients to take maximum advantage of the tools and products EPRI has published so that they don't end up reinventing the wheel. I see EPRI as a partner in license renewal. No company can do it all, even one like ours that has experience in the license renewal business. There are a lot of organizations and companies involved in license renewal, and EPRI is one of them."

Despite two successful license renewal applications to date, "for anyone to think that license renewal is now a breeze would be a fatal mistake," says Doroshuk. "It is a federal proceeding with many stakeholders involved, and it can be volatile. Our industry must pull together and get the proper resources in place to help every applicant get through the process. I tell nuclear service companies that want to get involved in license renewal to concentrate on their core competencies, like equipment upgrades, because now that licenses are starting to be renewed, we're seeing significant capital investments being made again. We have to cheer each other on and work together to make this a growth industry again. The cost of failure to the nation's economy is enormous."

Competition's challenge and opportunity

The positive shift in industry psychology triggered by the advent of the plant license renewal era has inevitably encouraged some observers and advocates for the industry to conceptually extrapolate from revitalization to rebirth for nuclear power in the United States. A few utility executives have even been heard to suggest that an order for a new nuclear generating unit could be placed in the foreseeable future—something that has not happened in nearly a quarter century.

Those executives would undoubtedly hasten to add that they are not ready to act just yet. Through most of the next decade, nuclear utilities may have their plates full obtaining license renewals and making the investments and upgrades that will position their existing workhorse plants as competitive generators for an ad-

Key EPRI License Renewal and Life-Cycle Management Reports

Calvert Cliffs

- *Calvert Cliffs License Renewal Aging Management Review Reports,* TR-110163-CD
- *Calvert Cliffs Nuclear Plant Asset Management Case Study,* TR-104615
- *Calvert Cliffs Life-Cycle Management/License Renewal Program: Reactor Pressure Vessel Evaluation,* TR-104509
- *Evaluation of EQ Options and Costs for Electrical Equipment for a License Renewal Period for Calvert Cliffs,* TR-104063

License Renewal and Aging Management

- *Non–Class 1 Mechanical Implementation Guideline and Mechanical Tools: B&W Owners Group Generic License Renewal Program,* TR-114882
- *Aging Effects for Structures and Structural Components: B&W Owners Group Generic License Renewal Program,* TR-114881
- *Class 1 Structures License Renewal Industry Report,* TR-103842
- *BWR Containments License Renewal Industry Report,* TR-103840
- *Guidelines to Implement License Renewal Technical Requirements,* TR-105090
- *Oconee Electrical Component Integrated Plant Assessment and Time-Limited Aging Analyses for License Renewal,* TR-107527
- *Basis for the Regulatory Decision on Calvert Cliffs License Renewal Application,* TR-107542-CD
- *Basis for the Regulatory Decision on Oconee License Renewal Application,* TR-111570-CD
- *Component Life Estimation: LWR Structural Materials Degradation Mechanisms,* NP-5461

Economics

- *Valuation and Management of Nuclear Assets: Nuclear Options Model (NOM, Version 1.0),* TR-107541
- *Life-Cycle Management Economics,* TR-104326

In the past decade, EPRI has produced a wealth of information on nuclear plant license renewal and life-cycle management, including about 30 reports on the successful Calvert Cliffs program and 10 license renewal industry reports. Key examples are listed here. These and other reports can be obtained from EPRI Customer Service, askepri@epri.com, 800-313-3774, or from John Carey, jcarey@epri.com, 650-855-2105.

The Road to License Renewal

The earliest documented study of extended nuclear power plant operation was initiated by EPRI in 1978 and published the following year. That planning study examined the technical and economic feasibility of operating nuclear plants beyond their nominal 30- to 40-year life as an alternative to decommissioning.

No significant technical obstacles that would preclude life extension were identified by that or subsequent early studies, but potential long-term aging issues were identified. These included reactor pressure vessel integrity, the potential need to replace electrical cable, and the potential deterioration of critical concrete structures like the containment structure. The studies concluded that, compared with new construction, extended operation was economically attractive even with large expenditures and substantial outages for plant refurbishment. The studies also pointed out that plants were experiencing a loss of licensed operating time because licenses were dated from the time a construction permit was issued rather than from the plant's completion date. The resulting corrective regulatory action added an average of six to seven years to plants' operating life.

1983–1987: Pilot plant studies

Detailed pilot plant life extension studies of the Monticello BWR plant of Northern States Power and the Surry PWR plant of Dominion Resources found no insurmountable technical issues for extended operation. The studies also demonstrated favorable economics, with a four-to-one ratio of benefits to costs. They concluded that the costs of managing the aging of critical components, including component replacement, would be the determining factor of a project's economic feasibility.

By providing an industry model for other plant-specific life extension studies, the EPRI work resulted in substantially increased industry interest in life extension.

The NRC, meanwhile, began an aging program for nuclear plant electrical components, which was later expanded to cover mechanical and structural components.

1988–1991: Lead plant projects and NRC rules

In response to industry requests, the NRC began to establish criteria for nuclear plant relicensing in the late 1980s. EPRI initiated lead plant license renewal projects at Monticello and Yankee Rowe and helped shape draft NRC documents published in those years. EPRI also completed 10 license renewal industry reports for major systems, structures, and components. The reports provided the basic model for all subsequent reviews of aging management. It was found that most aging issues were already managed under existing plant programs. A small number of component aging effects issues were identified that would require additional management during the extended license term. The regulatory basis for license renewal was established as the current license basis, which must be maintained during the renewal term through adequate aging management for components and structures.

RON MAY

Nuclear plant economics were rapidly changing during this period, with O&M costs increasing substantially. The critical economic test for nuclear license renewal was not whether it would be superior to new fossil plant construction, but whether nuclear plant production costs would be competitive in an unregulated electricity market during the renewal term.

Economic and regulatory issues led to the termination of the Monticello and Yankee Rowe projects and to the closure of Yankee Rowe. Although they did not achieve license renewal, the lead plant projects helped define the technical scope of license renewal and accelerated the NRC's establishment of relicensing criteria.

1991–1998: Calvert Cliffs and Oconee

The NRC's initial license renewal rule (10 CFR 54) was issued in 1991. EPRI and Baltimore Gas and Electric (BGE) launched a life-cycle management program at Calvert Cliffs to develop a long-term strategic plan. Economic analyses assumed deregulation and demonstrated that Calvert Cliffs could be competitive. Duke Power initiated a similar license renewal effort for Oconee. Three owners group programs were begun by utilities owning Babcock & Wilcox PWRs, Westinghouse PWRs, and General Electric BWRs.

EPRI funded license renewal projects at Calvert Cliffs and with the B&W Owners Group—projects that attempted to implement the requirements of 10 CFR 54 on selected systems and components. The work demonstrated a need to revise the license renewal rule to allow more credit for normal maintenance. Primarily as a result of these studies, the NRC amended the rule in 1995, limiting the review scope and allowing credit for ongoing management of the aging of active components. The revisions also eliminated reference to age-related degradation unique to license re-

newal and focused reviews on managing the effects of aging on long-lived passive components and structures. EPRI published a technical guideline for preparing a license renewal application, and this was later incorporated into a Nuclear Energy Institute industry guideline document (NEI 95-10).

Southern Nuclear and Entergy initiated license renewal programs for the Hatch plant and Arkansas Nuclear One unit 1, respectively, and several other utilities began planning studies. The NRC published its draft license renewal standard review plan and its generic environmental impact statement. The latter document substantially limited the number of environmental issues that must be considered on a plant-specific basis.

BGE and Duke Power submitted the first license renewal applications for Calvert Cliffs and Oconee, respectively, in 1998. The submittals attracted increased utility interest and led to the formation of license renewal programs for a number of other nuclear plants.

1999–2004: Standardization

The NRC set and met an aggressive schedule (approximately 24 months) for reviewing the Calvert Cliffs and Oconee plant license renewal applications. Calvert Cliffs received a 20-year license renewal in March 2000 and was followed by Oconee in May 2000; the operating term of each plant was thus extended to the mid-2030s.

EPRI, industry, and NRC efforts are now focused on standardizing the license renewal process and on substantially reducing both the cost of preparing a renewal application and the time required for NRC review. License renewal applications are currently being prepared for approximately 20 nuclear units. The goal for application preparation costs is to reduce them to around $3 million by 2004. NRC reviews will probably take 12–18 months, with the length dictated primarily by the public process required for reviewing the supplemental environmental impact statement for plant-specific license renewal. □

COURTESY SOUTHERN NUCLEAR

The twin-unit, 1848-MW Edwin I. Hatch plant in southeastern Georgia was the first BWR plant to apply to the NRC for license renewal. Southern Nuclear, Hatch's majority owner and operator, submitted an application in March 2000 for the two plant units, which began operating in 1975 and 1979, respectively.

ditional 20 years. It is more than a little ironic, however, that the tonic for nuclear power, viewed by some as emblematic of regulated monopolies that make choices insulated from real-world economics, would turn out to be the prospect of unbridled competition in a deregulated market. And the patient appears to thrive on the tonic.

"It's taken the industry 22 years to get fully into the business of license renewal and aging management, but from my perspective, the money invested in the necessary R&D to reach this point has been well worth it," says Duke's Robison. "We never would have gotten here if it had not been for EPRI continually focusing on the vision, saying that there has got to be a viable, standard way for utility people to think about how to take care of these plants and be able to renew the licenses."

"If you operate nuclear plants well, keep them in good running condition, and keep their capacity factors high, deregulation and license renewal provide the opportunity to make more money from them," says Entergy's Young. "Deregulation makes the plants more financially attractive than they would be otherwise. It enables a well-run nuclear plant to get into a position to add to the value of a company."

Concludes Doroshuk of Constellation Nuclear, "The industry will go through a period of major change in the next 10 years. There will be more consolidation of nuclear operating companies. We see deregulation and restructuring happening, but inconsistently from state to state. We all must continue to realize that safety, quality, and reliable operation of these plants are what got us here today and what will get us there tomorrow. So we need to continue to meet the expectations of the NRC; to continue to meet the responsibilities placed on us by the public and our local communities to operate these plants safely; and to team together to meet the challenges of consolidation, of deregulation, and of long-term plant operation. I think if we can do that, then nuclear energy as a source of electricity will continue to be part of a diverse fuel mix in the United States." ■

Further reading

Davies, M., "Justifying Plant Life Management," and D. Robinson and N. Broadhead, "Age Concern." *Nuclear Engineering International,* Vol. 45, No. 549 (April 2000), pp. 16–22.

Fisher, P., "Entergy to Join the License Renewal Queue," and R. D. MacDougall, "U.S. Nuclear Power—Can Competition Give It Renewed Life?" *Nuclear Engineering International,* Vol. 44, No. 539 (June 1999), pp. 32–37.

Nader, R. N., et al., "How Oconee Plans to Reach 60." *Nuclear Engineering International,* Vol. 43, No. 533 (December 1998), pp. 30–34.

Background information for this article was provided by John Carey (jcarey@epri.com).

In the Field

Demonstration and application of EPRI science and technology

GasVue Helps WAPA Bring SF_6 Leaks to Light

The GasVue camera for locating leaks of sulfur hexafluoride (SF_6) dielectric is helping the Western Area Power Administration minimize releases of that greenhouse gas from transmission equipment for a far-flung network of federal hydroelectric plants. WAPA recently launched an aggressive campaign to track down SF_6 leaks in its nearly 17,000-mile (27,000-km) high-voltage system, which transmits more than 10 GW of power from hydro plants in 15 central and western states. One of four federal power marketing agencies, WAPA has among its wholesale customers rural cooperatives, municipalities, Native American tribes, and other nonprofit entities.

SF_6 has a unique combination of chemical and physical properties that makes it ideal as an insulator in circuit breakers and other high-voltage switchgear; however, its efficient absorption of infrared energy and long atmospheric lifetime also make it a potent greenhouse gas, one of six targeted by international agreement for emissions reduction. The U.S. Environmental Protection Agency has called for voluntary participation by electric utilities and other industries in efforts to reduce, inventory, and track SF_6 emissions. WAPA's campaign seeks not only to detect and repair leaking equipment but also to modify maintenance practices in order to minimize releases.

At the heart of WAPA's fast-track effort is the GasVue camera, a state-of-the-art backscattering laser-based system developed with EPRI support by Laser Imaging Systems of Punta Gorda, Florida. The camera combines a carbon dioxide laser (tuned to an infrared absorption wavelength of SF_6) with an electronic infrared imaging system. As leaking SF_6 absorbs some of the laser light that bounces off a background surface, an image of the invisible gas is produced on the system's video display.

"We estimate that we have nearly 750 pieces of SF_6-filled equipment and about 200,000 pounds [91,000 kg] of the gas in place," says Dave Pearson, an environmental protection specialist at WAPA and the comanager of its SF_6 program. "Finding a cost-effective way to locate leaks was critical to the program's success."

PHOTOS BY LARRY ROMERO, COURTESY WAPA

The GasVue camera is proving its worth in the field, thanks to its ability to operate on energized equipment, says program comanager and electrical engineer Larry Romero. "It's an effective maintenance tool because it quickly and accurately locates SF_6 leaks, some as small as 2 pounds [0.9 kg] a year, on energized equipment at distances of up to 60 feet [18 m]." With traditional leak detection methods—halogen detectors and soapy water—equipment must be deenergized.

WAPA's program incorporates emissions training into routine maintenance training, stressing the use of emissions tracking data in predicting when and where leaks will develop so that maintenance schedules can be optimized. Other goals include preventing equipment failures, reducing SF_6 replacement costs, and improving personnel safety.

WAPA estimates the program's startup costs at $65,000 to $80,000, depending on the level of reduction in SF_6 replacement expenditures. Annual program costs are estimated at $40,000. "That's roughly 80% less than costs estimated using EPA guidelines," notes Pearson. "We think that's good business."

Inspections with the GasVue camera at eight substations in California, Colorado, Nebraska, and Wyoming have revealed only minimal leaks—"indicating that our current maintenance practices for SF_6-filled equipment are effective," says Romero. "However, as the cost of SF_6 increases and the emphasis on greenhouse gas emissions reduction continues, the need to improve how we manage this gas will become more critical."

EPRIsolutions offers SF_6 leak detection inspections and demonstrations with the GasVue camera. In addition, the recently

published *Practical Guide to SF_6 Handling Practices* (TR-113933), which includes information on procedures developed by utilities around the country, can help ensure that handling practices are safe, economical, and environmentally sound. The guide is available through EPRI Customer Service, 800-313-3774.

■ *For more information, contact Ken Loynes, kloynes@epri.com, 413-499-5712.*

COURTESY DETROIT EDISON

DOE's Dan Reicher (left) and DTE's Robert J. Buckler (third from left) tour the substation where HTS cable will be installed next year.

HTS Cable Project, Wire Manufacturing Advance

Detroit Edison has been recognized by the U.S. Department of Energy for its leadership in demonstrating new technology for high-temperature superconducting (HTS) power cable in a project supported by DOE and EPRI. Dan Reicher, assistant secretary of energy, said at a ceremony last spring that the company is playing a key role in advancing the world's first installation of HTS cable on an operating utility system. Such cable could enable utilities to keep pace with electricity demand growth in revitalized downtown areas like Detroit's while minimizing infrastructure disruption.

Presenting Detroit Edison officials with a commemorative plaque at the ceremony near the utility's Frisbie substation, where the 24-kV cable will be installed early next year, Reicher applauded the utility's commitment to the demonstration project. Noting Detroit Edison's various efforts to develop clean energy technologies—including fuel cells, landfill gas plants, and solar photovoltaics—and its planting of millions of trees through the government's Climate Challenge program, the assistant energy secretary called the HTS cable project "the icing on the cake."

"Because it is further down the road technologically, it requires a bigger commitment for a utility to step up and say 'we are going to do this,'" Reicher said. But with a utility like Detroit Edison stepping up and working in partnership with the government and various companies, he went on, "we actually think we are going to move this quickly into use, and the American people are going to be the beneficiaries."

HTS cable, which is supercooled to make it more efficient than conventional cable, promises to provide greater system reliability during periods of high electricity use. Learning how such new technology can work for both a utility and its customers is an important reason that Detroit Edison is "an eager participant in cutting-edge research and development projects like this one," said Robert J. Buckler, president of DTE Energy Distribution.

Among the other participants in the Detroit demonstration are Pirelli Cables and Systems, American Superconductor Corporation (ASC), and Lotepro Corporation. The project is a follow-on effort to the successful development and testing of a laboratory prototype HTS cable by Pirelli and EPRI in 1998.

Meanwhile, ASC continues to report progress in the commercial development of HTS power technology based on its first-generation high-performance wire, which, it says, carries over 100 times the electric current of copper wire with the same dimensions. The company recently announced plans for a greenfield wire-manufacturing plant in Massachusetts that is expected to be in full production (10,000 km per year) in early 2002.

In addition, ASC has invested in the development of second-generation HTS wire technology in an alliance with EPRI over the past four years. Under this alliance, ASC has exclusive rights to all EPRI technology on second-generation wire. The company has also obtained licenses for key components of second-generation wire technology from Oak Ridge National Laboratory and the Massachusetts Institute of Technology. These licenses add to the patents and patent applications generated in ASC's own laboratories. The new licensing agreement with Oak Ridge is accompanied by an agreement on wire R&D that ASC will fund.

According to CEO Greg Yurek, ASC has achieved world-leading laboratory results in short samples with its proprietary technology for low-cost, second-generation HTS wire. "This technology puts us on a path to beat the price-performance characteristics of copper wire," he says.

Adds Paul Grant, an executive scientist at EPRI, "ASC has been successful in developing what we believe to be the most commercially advantageous route to manufacturing second-generation HTS wire, which will open an even bigger market for superconducting products in the future." The company plans to further improve the performance of second-generation wire and to scale up to high-volume production of long-length wires in the next three to five years.

■ *For more information, contact Paul Grant, pgrant@epri.com, 650-855-2234.*

Technical Reports & Software

To place an order, call EPRI Customer Service at 800-313-3774 or 650-855-2121, and press 1 for software or 2 for technical reports. Target funders can download an Acrobat PDF file of a technical report by searching for the report number on EPRI's Web site (www.epri.com).

Energy Delivery

Assessment and Inspection Methods (AIM) for Overhead Transmission Lines
AP-108212
Target: Overhead Transmission
EPRI Project Manager: P. Lyons

Laser-Induced Lightning
TR-111787-V1
Target: Disaster Planning and Mitigation Technologies
EPRI Project Manager: R. Bernstein

Measurements and Modeling of Moisture Dynamics in Transformer Insulation Using Interdigital Dielectrometry Sensors
TR-113575
Target: Substation O&M
EPRI Project Manager: S. Lindgren

Measurement of Ancillary Services From Power Plants: Regulation, Load Following, and Black Start
TR-114246
Targets: Grid Planning and Development; Steam Turbines, Generators, and Balance of Plant
EPRI Project Manager: N. Abi-Samra

Review of Emerging Technologies for Condition Assessment of Underground Distribution Cable Assets
TR-114333
Target: Underground Distribution Infrastructure
EPRI Project Manager: B. Bernstein

Applications Guide: Distribution Capacity Planning With Distributed Resources
TR-114684
Target: Distributed Resources Business Strategy Development (and subtargets)
EPRI Project Manager: S. Chapel

Secondary Cable Study: Survey
TR-114735-V1
Target: Underground Distribution Infrastructure
EPRI Project Manager: B. Bernstein

Slow Release of Fungicides for Wood Poles: Commercialization/Technology Transfer
TR-114744
Target: Distribution Systems
EPRI Project Manager: B. Bernstein

Airborne Inventory and Inspection of Transmission Lines: AVCAN Systems Corp.'s Helicopter Patrol System (HPS)
TR-114773
Target: Overhead Transmission
EPRI Project Manager: M. Ostendorp

Application of TRELSS and Implementation of Value-Based Transmission Reliability Approach at Polish Power Grid Co.
TR-114816
Targets: Overhead Transmission; Grid Planning and Development
EPRI Project Manager: N. Abi-Samra

Environment

PISCES Water Characterization Field Study
AP-112433
Target: Plant Multimedia Toxics Characterization (PISCES)
EPRI Project Manager: P. Chu

Technical and Economic Evaluation of Coal Tar Dense Nonaqueous Phase Liquid (DNAPL) Pumping Techniques
TR-113101
Target: MGP Site Management
EPRI Project Manager: A. Jain

Solid-Phase Biotreatment Studies Using Manufactured Gas Plant Soils
TR-113102
Target: MGP Site Management
EPRI Project Manager: A. Jain

Comparative Carcinogenicity of Nickel Compounds: Review of Nickel Toxicity, Pharmacokinetics, and Mode of Action
TR-113883
Target: Air Toxics Health and Risk Assessment
EPRI Project Manager: J. Yager

Pilot Study: Occupational Health and Safety Surveillance Database
TR-113884
Target: Occupational Health and Safety
EPRI Project Manager: J. Yager

Lung Health and Risk Assessment After Respirable Fiber Exposure
TR-113922
Target: Occupational Health and Safety
EPRI Project Manager: L. Goldstein

Tools for Individual-Based Stream Fish Models
TR-114006
Target: Hydropower Relicensing Environmental Issues
EPRI Project Manager: D. Dixon

State-of-the-Science Review of Cyanide and Its Compounds at Former Manufactured Gas Plant Sites
TR-114121
Target: MGP Site Management
EPRI Project Manager: A. Quinn

Comprehensive Overview of Scientific Findings From Major Ozone Field Studies in North America and Europe
TR-114238
Target: Tropospheric Ozone and Precursors
EPRI Project Manager: A. Hansen

Environmental Assets Management Study, Revision 1: Case Study Report for Alliant Energy
TR-114443-R1
Target: Environmental Assets Management
EPRI Project Manager: P. Radcliffe

Literature Review of Background Polycyclic Aromatic Hydrocarbons
TR-114755
Target: MGP Site Management
EPRI Project Manager: A. Quinn

Accelerated Gas Chromatography/ Mass Spectrometry Analyses of Samples From Former Manufactured Gas Plant Sites
TR-114786
Target: MGP Site Management
EPRI Project Manager: A. Jain

Wavelet Applications for Modeling in the Atmospheric Sciences: Current Status and Potential Extensions (2nd Edition)
TR-114838
Targets: Tropospheric Ozone and Precursors; Assessment of the Potential Impacts of Global Climate Change
EPRI Project Managers: A. Hansen, M. Wildberger

Fossil and Renewable Generation

Mechanisms for Evaluating the Role of Hydroelectric Generation in Ancillary Service Markets
TR-111707
Target: Relicensing Forum
EPRI Project Manager: C. Sullivan

Role of Heterogeneous Nucleation in the Steam Condensation Process
TR-113524
Target: Steam Turbines, Generators, and Balance of Plant
EPRI Project Managers: B. Dooley, T. McCloskey

TAG® (Technical Assessment Guide): Supply Side, Vol. 1—1999 Product Slate
TR-113722 (see listing under Retail and Power Markets)

Assessment of Emission Control Technologies for Distributed Resource Options
TR-113743
Target: Emerging Distributed Resource Technologies
EPRI Project Manager: J. O'Sullivan

Gas Turbine Recuperators: Benefits and Status
TR-113745
Target: Emerging Distributed Resource Technologies
EPRI Project Manager: J. O'Sullivan

Investigation of Ammonia Adsorption on Fly Ash and Potential Impacts of Ammoniated Ash
TR-113777
Targets: Combustion By-Product Use; Special Uses for Class C Fly Ash; High-Value Uses of Fly Ash
EPRI Project Manager: D. O'Connor

Guidelines for Induced Flue Gas Recirculation, Vol. 1: Reducing Air/Gas System Resistance and Enhancing Fan Capacity
TR-113815
Target: Gas/Oil Boiler Performance/Combustion NO_x Control
EPRI Project Manager: D. Broske

Reciprocating Engines for Stationary Power Generation: Technology, Products, Players, and Business Issues
TR-113894
Target: Ultrahigh-Efficient Reciprocating Engines
EPRI Project Manager: J. O'Sullivan

Blade Life Management: Coating Systems
TR-113899
Target: Combustion Turbine and Combined-Cycle O&M
EPRI Project Manager: V. Viswanathan

Mastering the Markets: Gencos in Transition—Business and Organizational Change in Power Generation and Energy Trading Companies
TR-113998
Targets: Understanding Power and Fuel Markets and Generation Response; Fuel Supply and Procurement
EPRI Project Manager: J. Platt

Assessment of Distributed Resource Technologies
TR-114180
Target: Emerging Distributed Resource Technologies
EPRI Project Manager: D. Herman

Assessment of Microturbines as Distributed Generators
TR-114182
Target: Microturbine Products and Assessments
EPRI Project Manager: D. Herman

Environmental Performance, Regulation, and Permitting of Distributed Resources
TR-114183
Target: Distributed Resources Information and Tools for Business Strategy Development
EPRI Project Manager: D. Herman

Converting Existing Backup Generators Into Dispatchable System Resources: Assessing the Business Case
TR-114186
Target: Converting Existing Backup Power Into Dispatchable System Resources
EPRI Project Manager: D. Herman

Identifying and Capturing the Green Power Market: An EPRI Summary Perspective on U.S. Experience
TR-114202
Target: Renewable Technology Options and Green Power Marketing
EPRI Project Manager: T. Peterson

Building Community Support for Local Renewable and Green-Pricing Projects
TR-114203
Target: Renewable Technology Options and Green Power Marketing
EPRI Project Manager: T. Peterson

Green Power in Competitive Markets, 1999
TR-114210
Target: Renewable Technology Options and Green Power Marketing (and subtargets)
EPRI Project Manager: T. Peterson

Green Pricing Update, 1999
TR-114211
Target: Renewable Technology Options and Green Power Marketing (and subtargets)
EPRI Project Manager: T. Peterson

Measurement of Ancillary Services From Power Plants: Regulation, Load Following, and Black Start
TR-114246 (see listing under Energy Delivery)

Performance and Electrical Characterization Tests on a Microturbine Commercial Prototype
TR-114270
Target: Microturbine Products and Assessments
EPRI Project Manager: D. Herman

The U.S. Market Potential for Microturbines
TR-114271
Target: Microturbine Products and Assessments
EPRI Project Manager: D. Herman

Robotic System for the Maintenance of Boiler Hopper Systems in Power Plants
TR-114419
Target: I&C and Automation for Improved Plant Operations
EPRI Project Manager: R. Shankar

Demonstration of an Advanced Soot-blowing Control System: PowerGen's Kingsnorth Power Station
TR-114420
Target: I&C and Automation for Improved Plant Operations
EPRI Project Manager: R. Shankar

At-the-Burner Combustion Measurement Case Study Report: Demonstrations of Forney's OptiFlame and MK Engineering's MPV-1 Combustion Sensors
TR-114719
Target: I&C and Automation for Improved Plant Operations
EPRI Project Manager: J. Stallings

Materials for Ultrasupercritical Fossil Power Plants
TR-114750
Target: Boiler Life and Availability Improvement
EPRI Project Managers: V. Viswanathan, W. Bakker

Hydro Relicensing Forum: Relicensing Strategies
TR-114809
Targets: Hydropower Operations and Asset Management; Relicensing Forum
EPRI Project Manager: M. Bahleda

HydroTrac: Continuous Partial Discharge Monitor for Hydrogenerators
TR-114841
Target: Hydropower Operations and Asset Management
EPRI Project Manager: J. Stein

Fourth National Green Power Marketing Conference (1999)
TR-114878
Target: Renewable Technology Options and Green Power Marketing
EPRI Project Manager: T. Peterson

Nuclear Generation

BWR Water Chemistry Guidelines: 2000 Revision
TR-103515-R2
Target: Nuclear Power
EPRI Project Manager: C. Wood

Steam Generator Integrity Assessment Guidelines, Revision 1
TR-107621-R1
Target: Nuclear Power
EPRI Project Manager: M. Merilo

Balance-of-Plant Heat Exchanger Condition Assessment and Inspection Guide
TR-108009
Target: Nuclear Power
EPRI Project Manager: K. Krzywosz

Routine Preventive Maintenance Guidance for ABB HK Circuit Breakers
TR-109642 (supersedes NP-7410-V1P2)
Target: Nuclear Power
EPRI Project Manager: J. Sharkey

Effect of Environment on Fatigue Usage for Piping and Nozzles at Oconee Units 1, 2, and 3
TR-110120
Target: Nuclear Power
EPRI Project Manager: S. Rosinski

Containment Inspection Program Guide: ASME Section XI, Subsections IWE and IWL
AP-110698-R1
Target: Nuclear Power
EPRI Project Manager: H. Stephens

Mechanism of Hydrogen Pickup in Zirconium Base Alloys, Part 1: Autoradiography and Out-Reactor Loop Tests
TR-111384-P1
Target: Nuclear Power
EPRI Project Manager: S. Yagnik

Mechanism of Hydrogen Pickup in Zirconium Base Alloys, Part 3: Palladium Coating Tests
TR-111384-P3
Target: Nuclear Power
EPRI Project Manager: S. Yagnik

Hydramotor® Actuator Application and Maintenance Guide
TR-112181
Target: Nuclear Power
EPRI Project Manager: B. Knipschield

Polymer Specimen Removal Techniques for In-Service Cables
TR-112233
Target: Nuclear Power
EPRI Project Manager: G. Toman

Guidelines for Application of the EPRI Preventive Maintenance Basis
TR-112500
Targets: Nuclear Power; Technologies for Equipment Assessment and Maintenance
EPRI Project Manager: M. Bridges

Advanced Freeze Seal Monitoring Technology, Phase 1: Proof-of-Principle Demonstration
TR-112594
Target: Nuclear Power
EPRI Project Manager: J. Jenco

Revised Risk-Informed In-Service Inspection Evaluation Procedure
TR-112657, Rev. B-A
Target: Nuclear Power
EPRI Project Manager: J. Mitman

Condenser In-Leakage Guideline
TR-112819
Target: Nuclear Power
EPRI Project Manager: T. Eckert

Waste Logic Software Module for Decommissioning
AP-112872
Targets: LLW Management; Radiation Exposure Management
EPRI Project Manager: C. Hornibrook

Radwaste Desk Reference, Vol. 5: Transportation Update
TR-112920
Target: Nuclear Power
EPRI Project Manager: C. Hornibrook

Containment Decontamination Study: Review of Benefits and Impacts of PWR Containment Decontamination During Major Outages
TR-112921
Target: Nuclear Power
EPRI Project Manager: C. Hornibrook

BWR Activity Control: Plant Demonstration Results
TR-112981
Target: Nuclear Power
EPRI Project Manager: H. Ocken

Bearing Technology Topics, Vol. 2
TR-113059-V2
Target: Nuclear Power
EPRI Project Manager: M. Pugh

Two-Phase Pressure Drop Technology for Design and Analysis
TR-113189
Target: Nuclear Power
EPRI Project Manager: B. Chexal

Stress Corrosion Crack Growth Rate Measurements on Unsensitized Type 304 Stainless Steel in 288°C Water
TR-113489
Target: Nuclear Power
EPRI Project Manager: L. Nelson

A Refined Model for Prediction of Balanced Disk Globe Valve Thrust Requirements
TR-113558
Target: Nuclear Power
EPRI Project Manager: J. Hosler

Proceedings: 1999 EPRI International Low-Level-Waste Conference
TR-113702
Target: Nuclear Power
EPRI Project Managers: C. Hornibrook, S. Bushart

Proceedings: 1999 ASME-EPRI Radwaste Workshop
TR-113703
Target: Nuclear Power
EPRI Project Managers: C. Hornibrook, S. Bushart

Directional Stress Indices and Stress Intensification Factors for 90° Elbows (PWR Materials Reliability Project)
TR-113889
Target: Nuclear Power
EPRI Project Manager: R. Carter

Vibration Fatigue Testing of Socket Welds (PWR Materials Reliability Project)
TR-113890
Target: Nuclear Power
EPRI Project Manager: R. Carter

Evaluation of Capsule PWR-5 (EPRI-CRIEPI Integrated Reactor Vessel Surveillance Program)
TR-113891
Target: Nuclear Power
EPRI Project Manager: R. Carter

BWR Vessel and Internals Project: BWR Integrated Surveillance Program Plan
TR-114228
Target: Nuclear Power
EPRI Project Manager: R. Carter

Thermoelectric Materials
TR-114617
Target: Nuclear Power
EPRI Project Manager: J. Stringer

Risk-Informed Inspection for Steam Generators, Vol. 1: Deterministic Performance-Based Criteria
TR-114736-V1
Target: Nuclear Power
EPRI Project Manager: J. Benson

NP/LOMI Decontamination of the Laguna Verde 2 BWR
TR-114742
Target: Nuclear Power
EPRI Project Manager: H. Ocken

Improved Cobalt Removal: Compendium of Experience in Radioactive Cobalt Removal From Liquid Streams
TR-114751
Target: Nuclear Power
EPRI Project Managers: C. Hornibrook, S. Bushart

Inspection and Replacement of Baffle to Former Bolts at Point Beach 2 and Ginna: Processes, Equipment Design, and Equipment Qualification
TR-114779
Target: Nuclear Power
EPRI Project Manager: L. Nelson

Use of KB3 to Develop System Fault Trees for the TMI-1 PSA
TR-114880
Target: Nuclear Power
EPRI Project Manager: F. Rahn

Aging Effects for Structures and Structural Components: Structural Tools (B&W Owners Group Generic License Renewal Program)
TR-114881
Target: Nuclear Power
EPRI Project Manager: J. Carey

Non–Class 1 Mechanical Implementation Guideline and Mechanical Tools (B&W Owners Group Generic License Renewal Program)
TR-114882
Target: Nuclear Power
EPRI Project Manager: J. Carey

GOTHIC: Generation of Thermal-Hydraulic Information in Containments
Version 6.1a (UNIX; Windows 95, NT); 1000159
Target: Nuclear Power
EPRI Project Manager: L. Agee

RPVDATA: Reactor Vessel Materials Database
Version 2.0 (Windows 95, 98); AP-114785
Target: Nuclear Power
EPRI Project Manager: S. Rosinski

Retail and Power Markets

Electric Bus Compendium, Addendum 1
AD-111123
Target: Public Transportation
EPRI Project Manager: L. Sandell

TAG® (Technical Assessment Guide): Supply Side, Vol. 1—1999 Product Slate
TR-113722
Target: TAG™—Technology-Based Business Planning Information and Services
EPRI Project Manager: G. Ramachandran

Worldwide Assessment of Distributed Resources Markets
TR-114184
Target: Worldwide Business and Market Opportunities in Distributed Resources
EPRI Project Manager: D. Herman

Role of Distributed Resources in Business Strategies for Risk Management
TR-114185
Target: Distributed Resources as a Risk Management Hedge in Retail Portfolios
EPRI Project Manager: D. Herman

Electric Transportation Information Package (ETIP) Final Report, 1999
TR-114209
Targets: Building an Electric Transportation Industry; Industrial and Recreational Transportation
EPRI Project Manager: G. Krein

Commercial Nonintrusive Load Monitoring System Beta Test Results
TR-114236
Target: Information and Energy Management Services for Commercial and Industrial Customers
EPRI Project Manager: S. Drenker

Power Electronics in the Printing and Publishing Industry
TR-114242
Target: Power Electronics
EPRI Project Manager: B. Banerjee

Market Appeal of Green Power Technologies: Analysis of Residential Early Adopters
TR-114243
Target: Profiting From Innovative Customer Technologies
EPRI Project Manager: B. Kalweit

Retail Settlement Agent
TR-114253-R1
Target: Advanced Billing and Customer Operations Systems
EPRI Project Manager: D. Cain

Custom-ER Billing Engine (CBE)
TR-114254
Target: Advanced Billing and Customer Operations Systems
EPRI Project Manager: D. Cain

Retail Billing Engine
TR-114254-R1
Target: Advanced Billing and Customer Operations Systems
EPRI Project Manager: D. Cain

Customer Power Quality Solutions Package: Laboratory Test Results
TR-114269
Target: Managing Power Quality Programs
EPRI Project Manager: W. Moncrief

Information to Support Distribution Resources Business Strategies: Quantitative Analysis of DR Opportunities
TR-114272
Target: Distributed Resources Business Strategy Development
EPRI Project Manager: D. Herman

Regional Analysis of Business and Regulatory Climate for Distributed Resources
TR-114274
Target: Using Distributed Resources to Create Retail Business Strategic Advantage
EPRI Project Manager: D. Herman

Defining a Value Equation for Distributed Resources: Electronic and Health Care Industries
TR-114566
Target: Distributed Resources Business Strategy Development (and subtargets)
EPRI Project Manager: B. Kalweit

Electric Bus Subscription Purchase
TR-114642
Target: Public Transportation
EPRI Project Manager: L. Sandell

Hydronic Heating: A Practical Overview
TR-114793
Target: Residential and Commercial Business Development
EPRI Project Manager: J. Kesselring

Analysis of Aerosol-Based Duct Improvement Business in PEPCO's Service Territory
TR-114833
Target: Residential and Commercial Business Development
EPRI Project Manager: J. Kesselring

Contract Evaluator
Version 1.20 (Windows 95, 98, NT); AP-113198-P2R2
Target: Asset and Risk Management
EPRI Project Manager: A. Altman

MATES 5.0: MedWaste Alternative Technology Evaluation System
Version 5.0 (Excel); AP-113058
Target: Healthcare Industry
EPRI Project Manager: J. Bauch

Strategic Science and Technology

E-Commerce Applications and Issues for the Power Industry
TP-114659
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Complex Interactive Networks/Systems Initiative: Overview and Progress Report for Joint EPRI/DOD University Research Initiative
TP-114660
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Conceptual Design of a Strategic Power Infrastructure Defense System
TP-114661
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Intelligent Management of the Power Grid: An Anticipatory, Multiagent, High-Performance Computing Approach
TP-114662
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

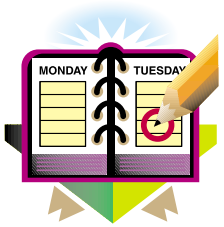
Modeling and Diagnosis Methods for Large-Scale Complex Networks
TP-114663
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Minimizing Failures While Maintaining Efficiency of Complex Interactive Networks and Systems
TP-114664
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Context-Dependent Network Agents
TP-114665
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

From Power Laws to Power Grids: A Mathematical and Computational Foundation for Complex Interactive Networks
TP-114666
Program: Strategic Science and Technology
EPRI Project Manager: M. Amin

Proceedings: EPRI Workshop on Condition and Remaining Life Assessment of Hot Gas Path Components of Combustion Turbines
1000044
Program: Strategic Science and Technology
EPRI Project Manager: V. Viswanathan



EPRI Events

October

8–11
Gasification Technologies Conference
San Francisco, California
Contact: Neville Holt, 650-855-2503

10–12
ASME Section XI Flaw Evaluation
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

10–12
Neural Networks and Fuzzy Logic Control With Engineering Applications
Kingston, Tennessee
Contact: Sherryl Stogner, 704-547-6174

10–13
RCM, Xvisor, MMW, and PDM Users Groups; SIM and IMD Working Group
Washington, D.C.
Contact: Marjorie Morales, 650-855-2254

16–20
Visual Examination: Level 1
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

17–19
NO_x Controls for Utility Boilers
Arlington, Virginia
Contact: Barbara McCarthy, 650-855-2127

18–19
Power Transformer and HVCT Working Group
Niagara Falls, Canada
Contact: Marjorie Morales, 650-855-2254

18–19
TFLASH 6.0 Training Seminar and Users Group Meeting
Lenox, Massachusetts
Contact: Kyle King, 413-448-2459

18–20
Value and Risk Training
Atlanta, Georgia
Contact: Maria Ramirez, 650-855-2621

19–20
Advanced In-Service Inspection and Testing of Live-Line Tools
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

19–20
Advanced Techniques for Providing Equipotential Zones for Live-Line Workers
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

19–20
Live-Line Working and Nonceramic Insulators
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

19–20
Live-Working Application Guide
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

19–20
Tools to Satisfy New OSHA Rules for Live Working
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

23–26
Tropospheric Aerosols: Science and Decisions in an International Community
Querétaro, Mexico
Contact: Alan Hansen, 650-855-2738

23–27
Simulator Instructor Techniques
Charlotte, North Carolina
Contact: Richard Pennington, 704-547-6105

23–November 3
Ultrasonic Examination: Level 2
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

24–25
Joint Technical Workshop: UWIG/TVP/Wind Powering America
Morgantown, West Virginia
Contact: Genesia Oliver, 650-855-2436

24–25
Power Quality Interest Group
Knoxville, Tennessee
Contact: Marsha Grossman, 650-855-2899

24–27
Short Course on Closed Feedwater Heaters
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

31–November 1
Motor-Generator Rewind Seminar
Farmington, New Mexico
Contact: Jim Oliver, 909-735-5239

November

1–2
Adjustable-Speed-Drive Applications
Knoxville, Tennessee
Contact: Lynn Stone, 972-556-6529

1–3
Forward Curve Introductory Training
Maui, Hawaii
Contact: Maria Ramirez, 650-855-2621

4–5
NMAC Shaft Alignment Workshop
Charlotte, North Carolina
Contact: Linda Parrish, 704-547-6061

6
Surge Arrester Testing and Monitoring
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

6–7
Simulator Specification and Procurement Workshop
Charlotte, North Carolina
Contact: Richard Pennington, 704-547-6105

6–10
Advanced Power Line Structural Analysis and Design Methods
Haslet, Texas
Contact: Gayle Robertson, 817-439-5900

6–10
NDE for Engineers
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

7–10
Simulator Acceptance Testing Procedures
Charlotte, North Carolina
Contact: Richard Pennington, 704-547-6105

8–9
FACTS Information Sharing and Updates
South Padre Island, Texas
Contact: Marjorie Morales, 650-855-2254

8–9
Hierarchical Control of Multiple FACTS Devices
South Padre Island, Texas
Contact: Marjorie Morales, 650-855-2254

8–9
Improved Solid-State Valves
South Padre Island, Texas
Contact: Marjorie Morales, 650-855-2254

8–9
Unified Power Flow Controller
South Padre Island, Texas
Contact: Marjorie Morales, 650-855-2254

8–9
Uninterruptible Substation
South Padre Island, Texas
Contact: Marjorie Morales, 650-855-2254

13–15
Balance-of-Plant Heat Exchanger NDE and Condition Assessment for Engineers
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

13–17
Visual Examination: Level 2
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

27–December 1
Ultrasonic Examination: Level 3
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

28–29
DayCor Camera Training Seminar
Lenox, Massachusetts
Contact: Judy MacPherson, 413-499-5701

December

4–6
Dynamic Rating for Overhead Lines
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

4–6
Effect of High-Temperature Operation
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

4–6
11th National Energy Services Conference
New Orleans, Louisiana
Contact: Ann Iverson, 650-855-1062

4–6
NDE Technical Skills Training: Level 3 Basic
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

4–6
Transformers: PTLOAD
Lenox, Massachusetts
Contact: Marjorie Morales, 650-855-2254

4–8
Instructor Station Operations
Charlotte, North Carolina
Contact: Richard Pennington, 704-547-6105

4–8
NDE Instructor Training
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

4–8
Operations Training for Nonoperators (Fossil Plants)
Kingston, Tennessee
Contact: Sherryl Stogner, 704-547-6174

5–6
Reliability Initiative Meeting
Phoenix, Arizona
Contact: Laura Ramos, 650-855-7919

5–7
Advanced Power Quality Training
Knoxville, Tennessee
Contact: Lynn Stone, 972-556-6529

5–7
Transmission Line Inspection Training Seminar
Haslet, Texas
Contact: Gayle Robertson, 817-439-5900

5–8
Maintenance and Repair of Heat Exchanger Equipment
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

6–8
NDE Technical Skills Training: Level 3 Specific
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

11
Fundamentals of Corrosion
Key West, Florida
Contact: Brent Lancaster, 704-547-6017

11–15
Digital I&C Upgrade
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

11–15
Visual Examination: Level 3
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

12–14
Corrosion and Degradation Conference
Key West, Florida
Contact: Brent Lancaster, 704-547-6017

12–14
Distribution Business Planning Workshop
Palo Alto, California
Contact: Andrea Duerr, 650-855-2719

13–15
Energy Book Workshop and Interest Group Meeting
Atlanta, Georgia
Contact: Maria Ramirez, 650-855-2621

January 2001

7–13
SCS (Society for Computer Simulation) Conference and EPRI Simulator and Training Center Interest Group Meeting
Phoenix, Arizona
Contact: Richard Pennington, 704-547-6105

8–10
Fourth Biannual Electric Utilities Environmental Conference
Tucson, Arizona
Contact: www.euec.com

15–17
Balance-of-Plant Heat Exchanger NDE and Condition Assessment for Engineers
Charlotte, North Carolina
Contact: Sherryl Stogner, 704-547-6174

15–19
Electrohydraulic Controls Workshop and Steam Turbine Generator Users Group
New Orleans, Louisiana
Contact: Linda Parrish, 704-547-6061

16–18
Modifying and Maintaining Structures and Conductors in Transmission Line Uprating
Haslet, Texas
Contact: Gayle Robertson, 817-439-5900

16–18
Utility Generator Predictive Maintenance and Refurbishment Conference
New Orleans, Louisiana
Contact: Barbara McCarthy, 650-855-2127

22–24
Pressure Relief Device Users Group
Orlando, Florida
Contact: Linda Parrish, 704-547-6061

22–25
AK/AKR and Magne-Blast Circuit Breaker Users Group
New Orleans, Louisiana
Contact: Linda Parrish, 704-547-6061

30–February 1
Heat Rate Improvement in a Deregulated Environment
Dallas, Texas
Contact: Barbara McCarthy, 650-855-2127

February

5–9
Infrared Thermography: Level 1
Kingston, Tennessee
Contact: Sherryl Stogner, 704-547-6174

18–21
Substations Equipment Diagnostics Conference
New Orleans, Louisiana
Contact: Marjorie Morales, 650-855-2254

June

4–6
Industrial and Recreational Transportation Conference
La Jolla, California
Contact: Laura Ramos, 650-855-7919

12–14
PQA 2001 North America
Pittsburgh, Pennsylvania
Contact: Barbara McCarthy, 650-855-2127