DOWNLOAD PDF RESULTS FROM THE NUCLEAR PLANT AGING RESEARCH PROGRAM

Chapter 1 : The Management of Aging in Nuclear Power Plant Concrete Structures

The Nuclear Plant Aging Research (NPAR) Program is a hardware oriented research program which has produced a large data base of information on equipment and system operating, maintenance, and testing.

History Origins The Nuclear binding energy of all natural elements in the periodic table. Higher values translate into more tightly bound nuclei and greater nuclear stability. Iron Fe is the end product of nucleosynthesis within the core of hydrogen fusing stars. The elements surrounding iron are the fission products of the fissionable actinides e. Except for iron, all other elemental nuclei have in theory the potential to be nuclear fuel, and the greater distance from iron the greater nuclear potential energy that could be released. However, he and other nuclear physics pioneers Niels Bohr and Albert Einstein believed harnessing the power of the atom for practical purposes anytime in the near future was unlikely, with Rutherford labeling such expectations "moonshine. Experiments bombarding uranium with neutrons led Fermi to believe he had created a new, transuranic element, which was dubbed hesperium. They determined that the relatively tiny neutron split the nucleus of the massive uranium atoms into two roughly equal pieces, contradicting Fermi. This work became part of the Manhattan Project , a massive secret U. The United States would test an atom bomb in July with the Trinity test , and eventually two such weapons were used in the atomic bombings of Hiroshima and Nagasaki. In August , the first widely distributed account of nuclear energy, in the form of the pocketbook The Atomic Age, discussed the peaceful future uses of nuclear energy and depicted a future where fossil fuels would go unused. Nobel laureate Glenn Seaborg , who later chaired the Atomic Energy Commission , is quoted as saying "there will be nuclear powered earth-to-moon shuttles , nuclear powered artificial hearts , plutonium heated swimming pools for SCUBA divers, and much more". This was followed by the Amendments to the Atomic Energy Act which allowed rapid declassification of U. The controllability of nuclear power reactors depends on the fact that a small fraction of neutrons resulting from fission are delayed , which makes the reactions easier to control. These are neutrons emitted by the decay of certain fission products. AEC, forerunner of the U. Nuclear Regulatory Commission and the United States Department of Energy spoke of electricity in the future being " too cheap to meter ". AEC itself had issued far more realistic testimony regarding nuclear fission to the U. Congress only months before, projecting that "costs can be brought down First connected to the national power grid on 27 August and officially opened by Queen Elizabeth II on 17 October The Shippingport Atomic Power Station in Shippingport, Pennsylvania was the first commercial reactor in the United States and was opened in One of the first organizations to develop nuclear power was the U. Navy , for the purpose of propelling submarines and aircraft carriers. Navy submarine fleet is made up entirely of nuclear-powered vessels, with 75 submarines in service. As of the Russian Navy was estimated to have 61 nuclear submarines in service; eight Soviet and Russian nuclear submarines have been lost at sea. Several serious nuclear and radiation accidents have involved nuclear submarine mishaps. Army also had a nuclear power program , beginning in The SL-1 was a U. It underwent a steam explosion and meltdown in January , which killed its three operators. The Soviet government kept this accident secret for about 30 years. The event was eventually rated at 6 on the seven-level INES scale third in severity only to the disasters at Chernobyl and Fukushima. Installed nuclear capacity initially rose relatively quickly, rising from less than 1 gigawatt GW in to GW in the late s, and GW in the late s. Since the late s worldwide capacity has risen much more slowly, reaching GW in Between around and , more than 50 GW of capacity was under construction peaking at over GW in the late s and early s â€" in , around 25 GW of new capacity was planned. More than two-thirds of all nuclear plants ordered after January were eventually cancelled. In the s U. The project was cancelled in and anti-nuclear success at Wyhl inspired opposition to nuclear power in other parts of Europe and North America. Several site occupations were also attempted. In the aftermath of the Three Mile Island accident in , some , people attended a demonstration against nuclear power in Bonn. Health and safety concerns, the accident at Three Mile Island , and the Chernobyl disaster played a part in stopping new plant construction in many countries, [42] although the public policy organization, the Brookings Institution states that new nuclear units, at the time of publishing in , had not been built in the United States because of soft demand for electricity, and cost overruns on nuclear plants due to regulatory issues and construction delays. Eventually, more than reactor orders in the United States were ultimately cancelled [52] and the construction of new reactors ground to a halt. A cover story in the February 11, , issue of Forbes magazine commented on the overall failure of the U. However, changes were made in both the reactors themselves use of a safer enrichment of uranium and in the control system prevention of disabling safety systems , amongst other things, to reduce the possibility of a duplicate accident. Opposition in Ireland and Poland prevented nuclear programs there, while Austria , Sweden and Italy influenced by Chernobyl voted in referendums to oppose or phase out nuclear power. In July , the Italian Parliament passed a law that cancelled the results of an earlier referendum and allowed the immediate start of the Italian nuclear program. It is the first EPR design, but problems with workmanship and supervision have created costly delays which led to an inquiry by the Finnish nuclear regulator STUK.

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Chapter 2 : Nuclear Plant Closures Bring Economic Pain To Cities And Towns | HuffPost

The US NRC's Nuclear Plant Aging Research (NPAR) Program is a hardware oriented research program which has produced a large data base of equipment and system operating, maintenance, and testing information.

Two utilities have announced their intent to submit applications for this second round. In Exelon expects to submit an application for its 2,megawatt Peach Bottom Atomic Power Station two boiling water reactor units , and Dominion Energy expects to submit for its 1,megawatt Surry Power Station two pressurized water reactor units in License renewal involves a systematic review of the plant, identification of degradation mechanisms, and the development of aging management programs. It proceeds through coordinated efforts on two distinct frontsâ€”regulatory and technical. Absent the second extensions, U. By , the current light water reactor fleet would be nearly gone see graphic below. The second round of license renewals represents a bridging strategy. It can potentially sustain a large source of carbon-free generation for an additional 20 years until deployment of the next generation of nuclear power units, including new light water reactors, small modular reactors, and other advanced reactor designs. In , the NRC staff issued a draft report that provides aging management guidance for plants seeking to operate from 60 to 80 years. Referencing more than EPRI studies, the document establishes the technical basis for the second round of license renewals. An earlier NRC document called the Generic Lessons Learned Report identifies and reviews nuclear plant aging management programs acceptable for first license renewals from 40 to 60 years. It draws on a broad body of technical expertise and decades of research in materials, engineering, and plant operations. Replacing any of these components would most likely be cost-prohibitive and lead to plant closure. For monitoring, irradiation surveillance capsules are placed inside, then periodically removed and tested. Extensive knowledge of embrittlement trends can be used to predict material properties out to 80 years of operation. Advanced welding techniques such as laser welding and friction stir welding are being developed to repair highly irradiated materials. Reactor internals operate in a harsh environment with respect to neutron bombardment, water chemistry, and temperatures. Researchers had anticipatedâ€”and confirmed with inspectionâ€”that baffle-former bolts could fail due to stress corrosion cracking. The NRC concluded that there is no safety problem, but utilities and EPRI responded by changing inspection protocols to combine visual and ultrasonic techniques during scheduled outages. Aging of Concrete and Civil Structures Concrete degradation can occur as a result of irradiation and chemical reactions. Such cracks can be sealed. Aging management includes monitoring concrete structures around the plant for structural integrity and movement. Inside containment, a key concern is irradiation of the bioshield, a large concrete structure that surrounds the reactor to reduce the effects of neutrons and protect workers. EPRI and others have conducted substantial research on how radiation impacts the concrete. Irradiation effects are unlikely to be a technical challenge for the second round of license renewals. Aging of Cables Heat, radiation, and water can accelerate aging of cable insulation. Degradation is typically localized because cables often run through many different environments from beginning to end. Some even run side-by-side with steam lines. Exposure and degradation vary segment by segment. Do we have to consider both temperature and radiation for predicting degradation, or is one predominant? A search for better monitoring technologies is underway. And we have tools that tell us we have an anomaly at a particular place on the cable, but not whether it is a problem. Together, Surry and Peach Bottom can usher in the second wave of life extension for the entire industry. Success in the U.

Chapter 3 : Nuclear power - Wikipedia

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Primary considerations related to management of their aging are noted: Several topics are noted where additional research would be of benefit. Other countries may not have a limit set on the plant operating license period but the utility must obtain a permanent renewal of its operating license subject to numerous and continuous justifications e. Due to this selected period, however, some structures and components may have been engineered on the basis of an expected year service life. The first of these units is nearing the end of its initial operating license period. In order to help assure an adequate energy supply, the USNRC has established a timely license renewal process and clear requirements that are needed to ensure safe plant operation for an extended plant life. In order to ensure the safe operation of nuclear power plants, it is essential that the effects of age-related degradation of plant structures, as well as systems and components, be assessed and managed during both the current operating license period as well as subsequent license renewal periods. This paper provides a description of nuclear power plant concrete structures, their operating experience, potential degradation mechanisms, approaches for assuring their continued performance, and areas where additional research would be beneficial. This paper describes large concrete structures that provide safety functions in nuclear power plants, their performance, potential factors that could infl uence their continued reliable performance, methods for estimating future performance, and desired research to provide added assurance of continued reliable and safe service. Concrete structures in nuclear power plants are described, a review of their operational experience provided, potential environmental effects that could potentially impact their performance provided, and methods described that can identify and mitigate any environmental effects that could impact continued reliable and safe performance of the concrete structures. The basic laws that regulate the design and construction of nuclear power plants are contained in Title 10 of the CFR, which is clarified by documents such as Regulatory Guides, U. A myriad of concrete-based structures are contained as part of a lightwater reactor LWR plant to provide foundation, support, shielding, and containment functions. Typical safety-related concrete structures contained in LWR plants may be grouped into four general categories: Only information related to primary containment structures for pressurized-water PWR and boiling-water reactor BWR plants is summarized here. Information on other concrete structures is provided elsewhere. The concrete containments are of three different functional designs: The PWR containment structure generally consists of a concrete basemat foundation, vertical cylindrical walls, and dome. Leak tightness of a containment is provided by a steel liner attached to the containment inside surfaces. Exposed surfaces of the carbon steel liner are typically painted to protect against corrosion and to facilitate decontamination should it be required. Depending on the functional design e. Figure 1 presents the Trojan nuclear plant cooling tower and post-tensioned concrete containment prior to decommissioning and demolition. Boiling-water reactor plants that utilize steel primary containments have reinforced concrete structures that serve as secondary containments or reactor buildings. These structures generally are safety-related because they provide additional radiation shielding; provide resistance to environmental and operational loadings; and house safetyrelated mechanical equipment, spent fuel, and the primary metal containment. Although these structures may be massive in cross section in order to meet shielding or load-bearing requirements, they generally have smaller elemental thicknesses than primary containments because of reduced exposure under postulated accident loadings. Operating Experience In general, the performance of nuclear power plant safety-related concrete structures has been very good. However, there have been a few isolated incidences of degradation that primarily occurred early in life and have been corrected. Examples of some of these problems include low concrete compressive strengths, voids under the post-tensioning tendon bearing plates, cracking of post-tensioning anchor heads, containment dome delaminations, misplaced steel reinforcement, post-tensioning system button-head deficiencies, and water-contaminated corrosion inhibitors. Several incidences of degradation related to environmental effects have occurred. Examples include corrosion of steel reinforcement in water intake structures, corrosion of post-tensioning tendon wires, leaching of tendon gallery concrete, low prestressing forces, and leakage of corrosion inhibitors from tendon sheaths. Other aging-related problems include cracking and spalling of containment dome concrete due to freezing and thawing, and corrosion of containment liners. As the plants age incidences of degradation are expected to increase, primarily due to environmental effects. Additional information on degradation of U. Serviceability of concrete has been incorporated into the codes through strength requirements and limitations on service load conditions in the structure e. Durability has been included in the design through specifications for maximum water-cement ratios, requirements for entrained air, minimum concrete cover over reinforcement, etc. Service-related degradation, however, can affect the performance of nuclear power plant concrete structures. As these plants mature, environmental factors are going to become increasingly important. Demonstration of continued safe and reliable operation of the plants will involve implementation of a program that effectively manages aging to ensure the availability of design safety functions throughout the plant service life. General guidance on developing an aging management program for concrete containment buildings has been developed. Primary mechanisms factors that, under unfavorable conditions can produce premature deterioration of reinforced concrete structures include those that impact either the concrete or steel reinforcing materials i. Degradation of the concrete can be caused by adverse performance of either its cement-paste matrix or aggregate materials under chemical or physical attack. In nearly all chemical and physical processes influencing the durability of concrete structures, dominant factors involved include the transport mechanisms within the pores and cracks, and the presence of water. Degradation of mild steel reinforcing materials can occur as a result of corrosion, irradiation, elevated temperature, or fatigue effects, with corrosion being the most likely form of attack. Posttensioning systems are susceptible to the same degradation mechanisms as mild steel reinforcement plus loss of prestressing force, primarily due to tendon relaxation, and concrete creep and shrinkage. Additional information on durability of nuclear power plant reinforced concrete structures is available. Improved damage models and guidelines for their use are required to predict failure probability of a degraded concrete structure, either at present or at some future point in time. Synergistic effects involving more than one degradation factor and the interaction of loading and environment also need to be investigated in more detail. Material Performance Nuclear safety-related concrete structures are composed of several constituents that, in concert, perform multiple functions e. Primarily, these constituents include the following material systems: Data on the long-term performance of the reinforced concrete materials is of importance for demonstrating the durability of the nuclear power plant concrete structures and in predicting their performance under the influence of pertinent aging factors and environmental stressors. This information also has application to establishing limits on hostile environmental exposure for these structures and to the development of inspection and maintenance programs that will prolong component service life and improve the probability of the component surviving an extreme event such as a loss-of-coolant accident. Reviews of research conducted on concrete materials and structures indicate that only limited data are available on the long-term 40 to 80 years properties of reinforced concrete materials. Limited data on the long-term performance of reinforced concrete materials reported in the literature, results from concrete cores removed from nuclear power plants, and specimens cast in conjunction with nuclear power plant facilities have been reported. With the availability of decommissioned nuclear power plants and plant modifications requiring removal of materials, opportunities exist to obtain samples for use in providing an improved understanding of the effects of extended exposure under the conditions found in nuclear power plants. Results could then be input into an operational database to help monitor and benchmark specific plant performance. Additional applications of a concrete material sampling activity would be for assessment of construction quality, development of improved damage models, assessment and validation of non-destructive testing methods, and evaluation of the performance of repair activities. With respect to ungrouted post-tensioning systems, current examination programs are adequate for determining the condition of the post-tensioning system materials and evaluating the effects of conventional degradation. Isolated incidences of wire failure due to corrosion have occurred. Leakage of tendon sheathing filler has occurred at a few plants, but except for the potential loss of corrosion protection, the problem appears to be primarily aesthetic. Although bonded prestressing tendons are less vulnerable to local damage than ungrouted tendons, the grouted tendons can not be visually inspected, mechanically tested, or re-tensioned in the event of larger than anticipated loss of prestress. Improved guidance on inservice inspection of grouted tendons is desired. Other potential research topics related to post-tensioning systems include development of an improved relationship between the end-anchorage force measured by the lift-off test and change in mean force along the tendon length for unbonded tendons. Assessment and management of aging in nuclear power plant concrete structures requires a more systematic approach than simple reliance on existing code margins of safety. A methodology to demonstrate the reliable and safe performance of these structures should include identification of structures important to public health and safety; identification of environmental stressors, aging mechanisms and their significance, and likely sites for occurrence; a monitoring or in-service-inspection-based methodology that includes criteria for resolution of existing conditions; and a remedial measures program. Component Selection The most effective structural condition assessment programs are those that focus on the components most important to safety and at risk due to environmental stressor effects. Aging assessment methodologies have been developed to provide a logical basis for identifying the critical concrete structural elements and degradation factors that can potentially impact the performance of these structures. A secondary goal is to identify environmental stressors or aging factor effects before they reach sufficient intensity to potentially degrade structural components. Routine observation, general visual inspections, leakage-rate tests, and destructive and nondestructive examinations are techniques available to identify areas of nuclear power plants that have experienced degradation. Determining the existing performance characteristics and extent and causes of any observed distress is accomplished through a structural condition assessment that routinely initiates with a general visual inspection to identify suspect areas followed by application of destructive or nondestructive examinations to quantify the extent and significance of any observed degradation. More detailed information on guidelines on conduct of surveys of existing civil engineering buildings is available. Some general guidance on assessment of nuclear power plant degradation is also available. Improved guidelines and criteria to aid in the interpretation of condition assessment results, including development of probability-based degradation acceptance limits, are desired. Nondestructive Examinations Application of nondestructive examination methods to nuclear power plant reinforced concrete structures presents challenges: Available methods are relatively good at identifying cracking, voids, and delaminations, and indicating the relative quality of concrete. Methods for determining concrete properties, however, are somewhat more qualitative than quantitative because they tend to be indirect in that they often require the development of correlation curves for relating a measured parameter e. Identification and description of methods for determining the strength of concrete and evaluation of concrete structures is provided elsewhere. Methods that can be used to inspect the basemat without the requirement for removal of material and techniques that can detect and assess corrosion are of particular interest. The most commonly used type of foundation for both concrete and steel nuclear power plant containments is a mat foundation, which is a flat, thick slab supporting the containment, its interior structures, and any shield building surrounding the containment. As such, the concrete foundation elements of nuclear power plants are typically either partially or totally inaccessible for inspection. Under conditions such as this the foundation structures are only accessible for inspection after removal of adjacent soil, coatings, waterproof materials, or portions of neighboring components or structures. As a result, indirect methods related to environmental qualification are often utilized to indicate the potential for degradation of the nuclear power plant concrete foundations. Remedial Methods Deterioration of reinforced concrete generally will result in cracking, spalling, or delamination of the cover concrete. Whenever damage is detected, corrective actions are taken to identify and eliminate the source of the problem thereby halting the degradation process. A remedial measures strategy is formulated based on the consequence of damage e. Basic guidance on the repair of degraded structures is available. In addition, improved understanding of how age-related degradation may affect dynamic properties e. Decisions as to whether to invest in maintenance and rehabilitation of structures, systems, and components as a condition for continued service and risk mitigation, and the appropriate level of investment, should consider the nature and level of uncertainties in their current condition and in future demands. Fragility analysis is a technique for assessing, in probabilistic terms in the presence of uncertainties, the capability of an engineered system to withstand a specified event. Fragility modeling requires a focus on the behavior of the system as a whole and, specifically, on things that can go wrong with the system. The fragility modeling process leads to a median-centered or likely estimate of system performance, coupled with an estimate of the variability or uncertainty in performance. The fragility modeling procedures applied to degraded concrete members can be used to assess the effects of degradation on plant risk and can lead to the development of probability-based degradation acceptance limits. This approach has been applied to a limited extent to degraded flexural members and shear walls. CONCLUSIONS In general, the performance of nuclear power plant concrete structures has been very good with the majority of identified problems initiating during construction and corrected at that time; however, aging of concrete structures occurs with the passage of time that can potentially result in degradation if its effects are not controlled. Periodic inspection, maintenance, and repair are key elements in managing the aging of concrete structures. Several areas have been identified where additional research would be of benefit to aging management of nuclear power plant concrete structures: Nuclear Regulatory Commission, March Nuclear Regulatory Commission, September Nuclear Regulatory Commission, July Nuclear Regulatory Commission, August International Atomic Energy Agency, June

Chapter 4 : Could Duke Energy's nuclear plants run for 80 years? - News - The Daily News - Jacksonville,

sion 2 to the Nuclear Plant Aging Research Program Plan. This plan defines the goals of the program, the current status of research, and summarizes Results.

Work in nuclear power reactor safety is focused on structural and seismic analysis, nuclear power plant license renewal and new license review support, and operational safety inspections. The work includes both engineering and analytical support, and the results of this work contribute to the development of NRC regulatory guidelines, licensing activities, and operating plant safety. Human factors work helps to ensure that the human-system interface in nuclear plants and other industrial facilities contributes to the overall safety of operations conducted there. These projects include development of a risk-informed methodology and human factors review and acceptance criteria in nuclear power plants for the NRC, and human factors guidance documents for digital systems and control rooms for DOE, in collaboration with industry. The Department is involved in a number of projects related to the safety of research reactors. The Department collaborates with industry, both domestic and foreign, on several large projects requiring specialized engineering and analysis capabilities. The center collects information on nuclear structure and nuclear cross-sections, maintains nuclear databases and makes use of modern information technology to disseminate the results. The data is kept in dedicated numerical libraries, which are periodically reevaluated and updated. The information is the product of the NNDC, cooperating data centers and other interested groups worldwide. In , the Center reached an important milestone of more than one million Web database retrievals. The NNDC has provided more than a half century of data and expertise to the world community, tracing its roots back to , when the Brookhaven Neutron Cross Section Compilation Group was formed in the Physics Department. Materials in Extreme Environments The Department continues to conduct research on materials in extreme environments for advanced energy systems. As part of that mission, the Group utilizes synchrotron characterization techniques such as diffraction, spectroscopy, and imaging and is developing sample chambers for the in-situ study of materials at the National Synchrotron Light Source NSLS. The Group is currently working on diverse materials science research for advanced energy systems including radiation effects in structural materials for nuclear reactors, new nanomaterials to extend the life and burn up of light water reactor nuclear fuels, carbonation of minerals for Enhanced Geothermal Energy Systems, increasing the reliability of batteries as emergency systems for nuclear plants and improved performance of accelerator target materials. Proposed facility to study radiation effects A new facility at the NSLS-II with a beamline for the real time and in-situ studies of materials in a radiation environment to study radioactive materials and radiation effects has been proposed. The beamline will consist of two end stations. Another end station will examine structural damage in previously irradiated materials using x-ray diffraction, tomography and absorption techniques. Fukushima Assistance The Department assisted the Department of Energy in modeling possible outcomes of the accident at the Fukushima nuclear facilities in Japan. One of ten national laboratories overseen and primarily funded by the Office of Science of the U. Department of Energy DOE , Brookhaven National Laboratory conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security. Brookhaven Lab also builds and operates major scientific facilities available to university, industry and government researchers.

Chapter 5 : Nuclear Plant Life Extension: A Strategic Bridge | EPRI Journal

A comprehensive Nuclear Plant Aging Research (NPAR) Program was implemented by the US NRC office of Nuclear Regulatory Research in to identify and resolve technical safety issues related to the aging of systems, structures, and components in operating nuclear power plants.

Stateline provides daily reporting and analysis on trends in state policy. The nuclear power plant plans to shut down in , a move applauded by environmental groups and Democratic Gov. Andrew Cuomo, but one that presents a budget crisis for the local Hendricks-Hudson school district, whose budget largely depends on taxes paid by Indian Point. Aging nuclear power plants are closing, doomed by the high cost of refurbishing them and the low price of natural gas. That is causing fiscal pain for municipalities that rely on revenue from the plants, and creating political pressure for state subsidies to forestall further shutdowns. That number is down from a peak of reactors in and will likely shrink further. Six reactors have shut down in the past five years, and eight more reactors are scheduled to close by at plants in California, Iowa, Massachusetts and Michigan. The closure of Indian Point, announced in January , capped decades of controversy over its safety, and was a victory for environmental groups and Democratic Gov. Andrew Cuomo, who had long opposed the plant. But the closure presents the local Hendricks-Hudson school district, where 2, children practice evacuation drills annually and nurses have iodide pills on hand in case of a radiation leak, with a budget crisis. A local task force, formed after the shutdown was announced, has hired an economic consultant. In California, the Diablo Canyon reactor, which employs 1, people, will shut down in A bill on Democratic Gov. Many nuclear power plants have curried public favor by being good corporate citizens. Officials in Londonderry Township, Pennsylvania, which hosts the plant, are helping power plant owner Exelon lobby for state aid. Development long ago chased wild pheasants from the area, and now nuclear power is disappearing as well. After the Vermont Yankee nuclear plant closed in , the 2, residents of Vernon, where the plant was located, found their tax base cut in half. As a result, police patrols, library hours and municipal staff were cut, too. Asking for State Help Four states have moved to shore up nuclear power plants financially despite opposition from some environmental groups, consumer advocates and the coal and natural gas power industries. Oyster Creek was not included in the subsidy plan. Connecticut enacted legislation last October that could allow its sole nuclear plant, the Millstone reactor in Waterford, to sell electricity at higher prices if Dominion Energy, its owner, can show the reactor is financially strapped. Some large environmental organizations are also pressing states to keep nuclear power plants operating. Groups including the Environmental Defense Fund and the Natural Resources Defense Council fear that energy from nuclear plants will be replaced by emissions-producing coal and natural gas plants. Keeping nuclear plants going for another decade will give states time to increase the amount of energy from wind and solar, and also cut emissions by improving energy efficiency, Clemmer said. New York and New Jersey will require half of their power to come from renewables by , and Connecticut will require 40 percent by that date. Illinois will require a quarter of its power to come from renewables by