GOING CRITICAL

THREE MILE ISLAND AND THE FEDERAL REFORM OF THE NUCLEAR POWER INDUSTRY

MYLES DAUTERIVE

On the morning of March 28, 1979, the United States endured a major crisis that heavily impacted its willingness to utilize nuclear technology for peaceful purposes. In the days that followed, Americans were inundated with reports that a major accident at the Three Mile Island Power Plant near Harrisburg, Pennsylvania, had resulted in the release of radioactive material into the atmosphere.[1] Caused by a combination of mechanical failure and human error, the critical failure of one of Three Mile Island's two primary reactors was America's first major commercial nuclear accident.[2] The accident itself provided tangible evidence that nuclear power represented an unsafe and unreliable venture.[3] As such, the accident at Three Mile Island fueled ongoing debate over the propriety of using atomic technology in non-military applications. Despite its negative impact on the image of nuclear power, the incident at Three Mile Island failed to undermine the nuclear power industry in the United States. Instead, the accident provided the impetus for a fundamental alteration of the nuclear power industry by forcing federal officials and industry representatives to develop new, highly stringent safety standards aimed at improving the operational practices of nuclear power plants.

While much has been written on the technical and managerial failures that contributed to the meltdown at Three Mile Island, relatively little research focuses on the accident's long-term impact on attempts to regulate the nuclear power industry. However, several works provide a brief overview of the incident's major historical

consequences.[4] Books like *TMI 25 Years Later: Three Mile Island Nuclear Power Impact and its Consequences,* co-authored by Bonnie A. Osif, Anthony J. Baratta, and Thomas W. Conkling, along with J. Samuel Walker's *Three Mile Island: A Nuclear Crisis in Historical Perspective* provide brief overviews of the federal government's response to Three Mile Island. However, these works provide relatively limited coverage of the specific actions the federal government pursued to prevent future accidents at nuclear power plants. Despite their broad view, these works, combined with a number of articles, such as James R. Temple's "The Nuclear Regulatory Commission and the Politics of Regulatory Reform: Since Three Mile Island," provide an excellent basis on which to begin an examination of the reform of the nuclear power industry.[5] Based on the contextual information provided by these works, as well as an analysis of a number of primary sources, this paper traces the response of the federal government to the accident at Three Mile Island through an examination of actions pursued by the Nuclear Regulatory Commission (NRC). This paper will also examine the development of new federal regulations governing the nuclear power industry between 1979 and 1985. Additionally, the following discussion will indicate the role of NRC reforms in facilitating the development of the modern nuclear power industry into a relatively safe venture. As such, the topic explored here will provide an analysis of the transformation of the American nuclear power industry following the accident at Three Mile Island.

The incident at Three Mile Island, which resulted in the release of radiation into the surrounding area, dramatically altered America's willingness to pursue the future development of nuclear power.[6] However, the Three Mile Island accident failed to curtail the operations of the nuclear power industry. Instead, it sparked a series of reform movements intended to improve the safety of

nuclear power plants. This process manifested itself in two forms. The first of these restructuring attempts originated within the nuclear power industry through the creation of a series of regulatory organizations charged with coordinating reform within the industry itself.[7] The second major reorganization effort was derived from the federal government through an attempt to alter existing regulatory organizations, such as the NRC, and restructure the nuclear power industry itself. Through the combination of actions pursued by the NRC and legislation passed by the US Congress, the federal government attempted to address several issues highlighted by the Three Mile Island accident. Focused primarily on improving the safety of nuclear power, the federal government adopted stringent inspection and safety protocols intended to help prevent the catastrophic mechanical failure of a nuclear reactor. Similarly, the NRC adopted new training standards in an effort to improve the reliability of power plant operators and the efficiency of nuclear power plant management practices. Federal reform efforts also focused on streamlining the nuclear power industry by overhauling the NRC's power plant licensing procedures. By focusing on this combination of the reform initiatives, this article argues that the Three Mile Island accident resulted in a change in the focus of federal legislation and regulatory standards between 1979 and 1985 that encouraged the creation of increasingly stringent safety standards.

In order to understand the true impact of the Three Mile Island accident, one must first explore the evolution of the nuclear power industry. Nuclear power began as a highly experimental technology. Utilizing research conducted during the Manhattan Project, the United States in the early 1950s began exploring the possibility of harnessing the power of nuclear reactions to generate electricity. On December 20, 1951, the United States activated the world's first nuclear reactor designed

specifically for the production of energy.[8] Dubbed EBR-1, this plutonium-fueled reactor demonstrated that nuclear power represented a potentially viable energy source. Building on this success, the military initiated several programs intended to explore the practical applications of nuclear power. Centering on the Navy, these programs sought to broaden the military uses of nuclear technologies by utilizing them in a non-weapon capacity. Developed by Adm. Hyman Rickover, the launch of the USS *Nautilus* in 1955 represented the first practical use of nuclear power. Using a prototype reactor, the *Nautilus* became the world's first nuclear-powered submarine.[9] This new design radically altered submarine warfare, allowing vessels to remain at sea for extended periods of time.[10] The launching of the *Nautilus* indicated that nuclear power held the potential to become a highly efficient and beneficial source of energy.

Despite the success of early experiments, nuclear power required the intervention of the federal government to gain a foothold in the civilian energy market. Beginning in the mid-1950s, the United States developed a series of legislative initiatives intended to spark the growth of the nuclear power industry. Passed in 1946 and later amended in 1954, the Atomic Energy Act represented the first of these initiatives. This piece of legislation created the Atomic Energy Commission (AEC). Despite heavy criticism that the agency focused more on promoting nuclear power than regulating it, the AEC served as the primary government agency responsible for regulating and promoting nuclear technologies.[11] The 1954 amendment to the Atomic Energy Act attempted to expedite the construction of nuclear power plants by granting utility companies interested in developing nuclear power plants access to large amounts of fissionable material and advanced research regarding nuclear technology.[12] As such, the Atomic Energy Act created the basic framework

for the often complex relationship between the nuclear power industry and the federal government. To further encourage the development of nuclear power, Congress passed the Price-Anderson Act in 1957. This piece of legislation provided companies operating nuclear power plants with approximately $560 million per reactor in insurance to help cover the costs of a potential accident.[13] This act removed a large amount of risk involved in the construction and operation of nuclear power plants. As such, the Atomic Energy Act and the Price-Anderson Act combined to provide a stable environment intended to encourage the development of nuclear power throughout the United States.

During the 1960s and 1970s, the nuclear power industry entered a period of expansion. Despite the proactive federal actions of the 1950s, the nuclear power industry required significant assistance to establish itself in the American energy market. Beginning in the 1960s, reactor developers such as General Electric (GE) and Westinghouse sought to create new markets for innovative reactor designs. In order to spur the growth of nuclear power in the United States, GE and Westinghouse developed the "Turn-key Program" in 1964. This initiative allowed power companies to purchase nuclear reactors for a fixed price set well below market value.[14] This allowed power companies to explore nuclear technology with relatively little risk, thereby stabilizing the nuclear power industry. The increased availability and affordability of nuclear reactors allowed for the development of plans to construct nearly ninety nuclear power plants throughout the United States.[15] Additionally, the turn-key program helped spur the development of plans to expand nuclear power production by nearly 60,000 megawatts.[16] Considering the production of over 983 billion kilowatt-hours of electricity in 1964 by all producers of electricity, the turn-key program represented an opportunity to

greatly expand America's electrical supply.[17] As such, the turn-key program resulted in the expansion of the nuclear power industry by improving the industry's access to valuable technological resources and by reducing the costs of constructing a nuclear power plant.

These developments combined with a series of federal legislation in the 1970s to help further the growth of nuclear power in the United States. The most significant of these pieces of legislation, the Nuclear Licensing and Sitting Act, attempted to provide federal support to companies operating nuclear power plants. Passed in 1978, this act reduced regulations governing the licensing of nuclear power plants. Specifically, it allowed the NRC to reduce its emphasis on mandatory safety hearings while also granting the organization the power to grant operating licenses prior to the completion of all licensing hearings.[18] While an attempt to help bolster the growth of nuclear power, the Nuclear Licensing and Sitting Act represented a pre-Three Mile Island sense of naiveté regarding the safety of nuclear power. Its emphasis on reducing the number of steps involved in licensing procedures indicated a willingness to sacrifice careful scrutiny and regulation in order to expedite the development of nuclear power in the United States. This indicates that federal regulations enacted prior to the Three Mile Island accident focused primarily on promoting the development of nuclear power rather than on creating stringent safety standards.

Despite its promising beginnings, the nuclear power industry in the United States encountered several major challenges during the 1970s. Among the most significant, the oil embargo enacted by the Organization of Petroleum Exporting Countries (OPEC) in 1973 threatened to undermine the industry's stability and expansion. A significant spike in oil prices caused by the OPEC embargo initially bolstered hopes that nuclear power held the potential to become a major player in the American energy

market.[19] However, a severe economic recession in the early- and mid-1970s forced American utility companies operating nuclear power plants to limit expansion of their operations. Consequently, they were forced in 1974 to cancel the construction of several proposed power plants capable of collectively producing nearly 130,000 megawatts of power annually.[20] This, combined with a significant increase in the price of plutonium between 1974 and 1976, made the production of nuclear power a highly expensive endeavor.[21] Additionally, during the mid-1970s US demand for and consumption of energy stagnated.[22] This decreased demand for energy, combined with increasing costs, severely undermined economic interests in nuclear power. Thus, economic troubles during the 1970s threatened the stability of nuclear power utilities throughout the United States.

The late 1960s and early 1970s witnessed the rise of an intense social and intellectual opposition to nuclear power. Formed in 1969, the Union of Concerned Scientists (UCS) challenged the credibility of the nuclear power industry. Engaged primarily on examining the safety and technological aspects of nuclear power, the UCS argued that existing safety standards regarding the operation of nuclear reactors were ineffective.[23] Initially formed in response to military experiments with nuclear technologies, the UCS heavily criticized safety standards regarding emergency reactor shutdown procedures.[24] Focused specifically on emergency shutdowns initiated by a loss of coolant in a reactor, the UCS claimed emergency procedures left little if any room for error, thereby increasing the chance that a minor mechanical or human failure could result in devastating consequences.[25] While not entirely opposed to the continued development of nuclear power, the organization's focus on safety protocols indicated the emergence of a new hesitancy to accept nuclear technologies in a civilian setting. This sentiment

further manifested itself through the emergence of grass-roots anti-nuclear groups such as the Clamshell Alliance. Motivated by environmental and safety concerns, the Clamshell Alliance represented a shift in the ideologies of the anti-nuclear movement.[26] While earlier groups, such as the UCS, called for strengthened safety protocols, the Clamshell Alliance and other anti-nuclear movements attempted to curtail the growth of the nuclear power industry.[27] As such, the combination of intellectual and grassroots movements further challenged the nuclear power industry by placing increased scrutiny on its safety practices and potentially negative influence on communities across the nation.

Despite the concerns of the UCS and Clamshell Alliance, nuclear power represented a small, but growing, portion of the American energy market in the 1970s. In 1974, nuclear power companies generated 100.5 billion kilowatt-hours of electricity, accounting for roughly 7% of America's electrical production.[28] As such, nuclear power ranked behind coal, oil, and natural gas forms of electrical generation, which provided 84.6% of America's total electrical production in 1974.[29] However, following the OPEC embargo, the Nixon Administration encouraged the further development of nuclear power. Specifically, President Nixon set high goals for the nuclear power industry, proposing that it provide nearly 30% to 40% of America's electricity by the early 1990s.[30] Despite the economic challenges discussed above, the nuclear power industry managed to increase its output, providing nearly 11% of America's electrical production by 1982.[31] Significantly, this allowed the nuclear power industry to generate the energy equivalent of 1.3 million barrels of oil per day by 1982.[32] This boost in production accompanied an increase in the number of nuclear power plants operating throughout the United States. By 1981, the United States possessed seventy-one active nuclear power

plants that produced nearly 53,000 annually.[33] This, combined with plans calling for the construction of nearly sixty additional nuclear power plants, indicated nuclear power's growing role as a viable source of energy for the United States.[34]

Reform measures prior to the Three Mile Island accident failed to significantly alter safety standards. Beginning with the passage of the Energy Reorganization Act in 1974, the federal government attempted to restructure its oversight of the nuclear power industry. This act, responsible primarily for dissolving the Atomic Energy Commission, an agency criticized heavily for placing a great deal of emphasis on promoting nuclear power rather than regulating it, created an entirely new system of organizations charged separately with the promotion and regulation of nuclear utilities. Significantly, the Energy Reorganization Act created a new government oversight organization known as the Nuclear Regulatory Commission (NRC).[35] The NRC based its authority on a tri-partite division of responsibilities between the Offices of Nuclear Reactor Regulation, Nuclear Regulatory Research, and Nuclear Safety and Safeguards. Endowed with a mandate to regulate the activities of the nuclear power industry, the NRC held the responsibility to oversee the construction and licensing of all nuclear power plants and the development of technical safety standards. Additionally, the Energy Reorganization Act stipulated that each office fell under the control of a single executive director of operations, who in turn served under a commission of five individuals appointed by the president of the United States. However, the reorganization of federal regulatory agencies failed to provide the NRC with a clear structure of authority. As such, the directors of the various offices within the NRC remained free to report to either the executive director of operations or directly to the commissioners.[36] Thus, despite a clear mandate, the NRC

remained a somewhat ineffective organization due to its inability to establish clear lines of communication and authority. Furthermore, between 1974 and 1979 the NRC failed to significantly improve the safety standards of the nuclear power industry. As discussed previously, the NRC held the power to grant operating licenses to nuclear power plants before the completion of required licensing and safety hearings. This indicates that the NRC maintained a focus on promoting the development of nuclear power rather than focusing specifically on developing stringent safety standards. Thus, the NRC's complex system of authority, combined with its conflicting interests to promote and regulate the nuclear power industry, limited the organization's ability to develop stringent safety standards.

Prior to Three Mile Island, the NRC failed to create strong and effective standards for the selection and hiring of power plant operators. The education standards set by the NRC allowed an individual with relatively little education and experience to gain a reactor operator's license or certification as a senior operator. The certification process for a reactor operator's license required that an individual possess a high-school education and at least two years of experience in a power plant. These standards also required that an individual possess only one year of experience working in a nuclear power plant.[37] Interestingly, this requirement failed to specify exactly what constituted an appropriate level of experience. As such, these lax standards allowed an individual with little theoretical or practical experience to operate a nuclear reactor. Compounding this issue, NRC regulations failed to set strict standards regarding the selection of plant managers. Qualification standards for a plant manager certification required that one possess at least "four years of responsible power plant experience" and at least one year of experience in a nuclear plant.[38] While these

requirements ensured that individuals with a fair amount of experience in the energy industry held management positions, they failed to ensure that managers had significant experience with nuclear power.

Safety standards set by the NRC also failed to ensure that power plant operators received sufficient training. According to a special report submitted to the Senate Committee on Environment and Public Works in 1980, reactor operator exams established a fairly low score as a passing grade. Designating a score of 70% as sufficient to pass a licensing exam, these assessments allowed license applicants to gain certification despite a lack of proficiency.[39] Additionally, operator licensing exams and programs neither mandated nor provided additional training to those applicants who passed their examinations with low scores. Significantly, the failure to ensure supplemental training allowed relatively inexperienced operators possessing an incomplete knowledge of nuclear principles and reactor operations to gain certification.

Compounding this issue, training programs failed to provide operators with the knowledge necessary to handle emergency situations. NRC training standards placed little emphasis on emergency management. Established training protocols focused on preparing operators to follow a set of established procedures that addressed minor malfunctions and daily routines.[40] These training protocols failed to provide any instruction in the skills necessary to prevent or manage the occurrence of a major nuclear accident. Thus, these training standards taught operators to address predetermined issues, neglecting to teach them to address new and unforeseen problems. Additionally, the operation of a nuclear power plant provided little opportunity for on-the job-training. Prior to the Three Mile Island accident, nuclear power plant operators remained relatively uninvolved in the management of a nuclear reactor. Concerning themselves almost exclusively with the start-

up and shutdown procedures of a reactor, operators remained fairly passive in the daily operations of nuclear power plants. As such, reactor operators served as simple monitors responsible only for making occasional minor adjustments.[41] Thus, the training provided to nuclear operators afforded little opportunity to learn the creative thinking and practical skills necessary to prevent a major nuclear accident.

The accident at Three Mile Island revealed major flaws in the practices of the nuclear power industry and in the regulations created by the Nuclear Regulatory Commission. In order to understand the long-term impacts of Three Mile Island, one must first study the causes of the accident. The initial problems faced by the Three Mile Island power plant stemmed from mechanical failures. During normal operations, reactor number two at Three Mile Island experienced a minor mechanical glitch. An automated valve known as a Pilot Operated Release Valve (PORV) opened in response to increased pressure levels in the water-based coolant used to maintain a stable nuclear reaction. Although a normal occurrence, the valve failed to close itself, thereby allowing nearly one million gallons of radioactive water to spill out of the core and into the plant itself.[42] The drop in coolant levels activated the plant's automated emergency systems, causing reserve pumps to divert water to the reactor core in an attempt to maintain a constant pressure. Significantly, the leakage of contaminated coolant fluid resulted in an overflow of Three Mile Island's liquid storage tanks, resulting in the release of nearly one millirem per hour of radioactive material throughout the plant. This released a total of 240 millirems of radiation over the ten-day course of the accident.[43] However, mechanical failures represented only a small part of the root causes of the Three Mile Island accident.

Post-accident investigations revealed that human error and poorly designed reactor control room interfaces formed the primary cause of the Three Mile Island accident. The failure of Three Mile Island's operators to recognize the malfunction of the plant's PORV system indicated that reactor control rooms based themselves on a highly complicated design that often provided vague and unclear data.[44] This same issue also demonstrated the shortfalls of reactor operator training programs. Considering the relatively lenient training standards discussed above, Three Mile Island operators relied heavily on technical readouts that failed to indicate a specific source of the plant's mechanical failures. This led Three Mile Island's operator's to misdiagnose the source of the plant's problems, thereby allowing the workers to adopt incorrect and ineffective counter measures.[45] Additionally, this incident highlighted many operators' inability to determine alternative sources of various problems. These two factors helped initiate attempts to reform both the safety and operational protocols of the nuclear power industry.

Following Three Mile Island, the federal government launched a number of investigations in an attempt to determine the causes of the accident and possible solutions to help prevent future incidents. The most significant of these, the Kemeny Commission, represented an attempt to develop an in-depth understanding of both the technical and structural flaws that contributed to the Three Mile Island accident. This commission consisted of a number of representatives from a variety of nuclear-related fields.[46] Based around the promotion of "fundamental changes" in the "organization, procedures, and practices…of the NRC," the final report of the Kemeny Commission focused on the reformation of federal nuclear oversight organizations and their role in determining industry regulations.[47] Specifically, the

Commission focused on the role of human error in the Three Mile Island accident by identifying it as the result of poor training, confusing regulations, and a mindset in the industry and the NRC that placed a heavy emphasis on maintaining equipment rather than on improving human abilities.[48] As such, the Kemeny Commission called on the NRC to adopt a series of reforms that focused specifically on the prevention of human error and its role in causing nuclear accidents.[49] Thus, the report laid the foundations for long-term federal reform efforts throughout the 1980s.

The federal attempt to reform the nuclear power industry embodied itself in the reorganization of the Nuclear Regulatory Commission and the implementation of new policies intended to boost the organization's influence. In 1979, the Kemeny Commission called for the dissolution of the NRC and the establishment of a new regulatory agency under the jurisdiction of the president of the United States.[50] The drastic nature of this proposal caused many federal officials, including President Jimmy Carter, to seek alternative reforms. Interestingly, President Carter implemented a plan for the reorganization of the NRC that allowed the organization to retain its basic structure. This plan also granted increased power and responsibilities to the Commission's chairman and executive director of operations.[51] This indicated a willingness on the part of the federal government to increase the efficiency and effectiveness of regulatory organizations.

Beginning in 1979, the NRC attempted to bolster its influence over nuclear power companies. In order to accomplish this, the NRC developed and implemented a new initiative known as the "Resident Inspector Program." Based on providing a uniform system of enforcement for federal regulations, the Resident Inspector Program placed one NRC licensed inspector at every nuclear power plant throughout the country.[52] This program allowed the NRC

to monitor all power plant operations, thereby providing the organization increased control over the nuclear power industry. This program also represented an attempt to proactively prevent mechanical failures in nuclear power plants. According to Karl V. Seyfrit, a deputy regional administrator for the NRC, these inspections prevented nuclear accidents by allowing inspectors and power plant personnel to "take corrective actions just as soon as possible" should a problem arise.[53] By 1981 nearly 400 inspectors enforced NRC regulations at power plants throughout the country.[54] This increased authority over the nuclear power industry reflected a fundamental shift in the focus of the NRC following the Three Mile Island accident. By actively enforcing regulatory standards, the NRC shed its primary responsibility of licensing the construction of nuclear power plants, becoming a full-fledged regulatory agency that directly influenced the daily operations of nuclear plants throughout the country.[55]

To further bolster its control over the nuclear power industry, the NRC advocated for the development and implementation of a highly stringent system of fines and punishments for safety violations. In 1980, the NRC managed to secure the passage of laws that dramatically increased fines from $5,000 to $100,000 per safety violation, thereby strengthening its notoriously weak sanctions.[56] This placed economic pressure on utilities operating nuclear power plants to comply with federal regulations. The NRC further strengthened its regulation enforcement policies by establishing harsh criminal penalties, including imprisonment and steep fines, for those found in violation of federal regulations.[57] While primarily an attempt to strengthen the NRC's regulation enforcement protocols, these reforms created an increased level of accountability for both power plant operators and the nuclear power industry as a whole. The combination of stringent fines and increased NRC oversight forced nuclear power companies

to maintain strict safety and operational protocols in order to avoid federal sanctions.

Despite its attempts to quickly increase the strictness of federal inspections and oversight, the NRC proved sluggish in developing new safety standards. Beginning in 1979, the NRC adopted a series of recommendations created by its subsidiary Advisory Committee on Reactor Safeguards (ACRS). These standards focused primarily on two major areas. First, recommendations called on the industry to ensure the safety of communities surrounding nuclear plants by reducing possible threats to human lives.[58] Second, the ACRS recommendations pressed nuclear power companies to adopt a more proactive role in anticipating and addressing possible reactor problems.[59] Despite a distinct lack of legislative power, these recommendations attempted to create a comprehensive set of safety regulations that upheld the best interests of both the nuclear power utilities and the general public. Additionally, these recommendations indicated that a reformation of safety protocols required an emphasis on both human and technical variables, thereby ensuring that nuclear power companies accounted for multiple factors in their daily operations.

Building on the ACRS proposals, the Nuclear Regulatory Organization (NRO) developed an in-depth safety policy statement that established both qualitative and quantitative goals for the nuclear industry. Bearing a strong resemblance to the ACRS proposal, the NRO safety goals required nuclear power plants to minimize the potential threats they posed to human lives by protecting the general public from the possible consequences of a nuclear accident.[60] However, this new set of safety goals also created a series of numerical goals for the nuclear industry. Specifically, these proposals stipulated that a nuclear power plant could not cause more than a 0.1% increase in rates of cancer or accidental death than those set

by other major industries.[61] Significantly, this marked one of the first attempts to create a clear set of legislation intended to strengthen nuclear power safety standards. By providing a numerical value for acceptable cancer and fatality rates, the NRO allowed nuclear utilities the ability to develop new safety measures intended to create a less harmful and more publically oriented nuclear power industry.

Despite the in-depth focus of the previously discussed standards, the NRC continued to develop increasingly complex safety guideless. On March 14, 1983 the Nuclear Regulatory Commission adopted a new safety policy. Utilizing language similar to previous guidelines, these new standards mandated that "individual members of the public should bear no significant risk to life and health."[62] While these broad requirements contained little legislative value, their dedication to protecting the public provided the ideological basis for the NRC's safety regulations. These standards also adopted elements of previous safety goals, mandating that nuclear power plants reduce their potential to increase rates of death resulting from cancer.[63] Additionally, these new standards examined the expected costs of implementing new safety technologies, arguing that utility companies owning nuclear power plants spent less than $1,000 for every person-rem of radiation avoided during the operation of a nuclear reactor.[64] This argument indicated that safety technologies represented a relatively inexpensive way of preventing a major accident.

Immediately following the Three Mile Island accident, the NRC attempted to reform its licensing protocols for nuclear power plants. In an open break with previous policies, the NRC temporarily suspended all reactor license applications pending further investigation of Three Mile Island.[65] This temporary moratorium allowed the NRC an opportunity to reevaluate and strengthen its

licensing standards. In 1979, the NRC created a new policy mandating all nuclear power companies to submit an emergency planning report with their license applications. This requirement called on utilities to develop a comprehensive set of plans detailing various emergency procedures intended to minimize the effects of a possible nuclear accident.[66] Despite the NRC's unwillingness to issue any new reactor licenses following Three Mile Island, this requirement indicated an increased focus on improving safety and the effective management of nuclear accidents.

However, despite an increased focus on safety, some NRC reforms maintained an interest in promoting the development of the nuclear power industry. In a letter submitted during a congressional hearing on April 1, 1981, Joseph M. Hendrie, a former chairman and commissioner of the NRC, proposed a plan allowing nuclear power plants to begin limited operations before receiving full licensure. This proposal authorized nuclear power companies to initiate fueling and testing procedures for reactors undergoing NRC licensing reviews.[67] While a seemingly simple proposal, the development of the "interim license" program indicated a growing interest among members of the NRC in reducing construction and licensing delays, impeding the development of new nuclear power plants in the United States.[68] However, the failure of nuclear utilities to order the construction of even a single reactor or power plant since 1979 indicated that this proposal, and others like it, failed to renew commercial interest in the development of nuclear power.[69]

The NRC further augmented its licensing reform efforts through an attempt to streamline the licensing process. To accomplish this, the NRC adopted new policies intended to help reduce the nearly decade-long process involved in securing an operating license for a nuclear power plant.[70] Interestingly, the NRC attempted to

abandon its requirement that all objections to the construction of a nuclear power plant receive a public hearing.[71] Through this, the NRC hoped to limit the rights of "third party intervenors" and their ability to challenge NRC standards by voicing their concerns over possible safety hazards posed by nuclear power plants.[72] While intended to help expedite the licensing process, this proposed policy removed public opinion as a major factor in determining the approval of a proposed nuclear power plant. Additionally, this reform indicated an attempt to boost the effectiveness of licensing procedures. Between 1979 and 1981 the NRC issued nearly 1,600 "no significant hazard" license amendments due to public challenges regarding a variety of safety issues.[73] As such, by removing a source of possible challenges to NRC regulations, the organization indicated a willingness to suspend its focus on safety in an effort to facilitate the interests of the nuclear power industry. Thus, this series of licensing reforms indicates that the NRC never completely abandoned its pre-Three Mile Island focus on promoting the development of nuclear power.

Federal reform efforts culminated in the National Nuclear Power Plant Personnel Training Act of 1985. Intended to standardize reactor operator training standards, this act augmented existing industry standards by implementing a single set of nationally recognized training practices through the creation of the federally administered National Academy for Nuclear Power Safety (NANAPS).[74] Intended to provide training to all nuclear power reactor operators and support personnel, the academy developed a curriculum based on teaching its students the principles "necessary and appropriate for the safe operation of civilian nuclear power plants."[75] Furthermore, the curriculum adopted by the academy offered a series of training programs intended to fulfill the educational needs mandated by federal licensing

requirements for a variety of positions throughout the nuclear power industry.[76] This indicated an attempt to dramatically improve training standards by requiring all nuclear power personnel to adhere to a standardized set of rigid protocols. Additionally, the NANAPS curriculum based itself on training and safety standards set by the NRC and nuclear power industry. As such, the creation of the National Academy for Nuclear Power Safety represented an attempt to combine the previously independent reform efforts of the federal government and nuclear power companies.

The reforms initiated by the NRC, combined with measures developed by the nuclear power industry following the Three Mile Island accident, formed the basis of the modern American nuclear power industry. The combination of the reforms discussed above and those pursued separately by the nuclear power industry led to a noticeable decrease in emergency "scrams."[77] In the years between 1980 and 1985 the average number of unplanned automatic scrams per unit dropped from 7.3 to 4.5 annually.[78] The improved safety standards set by the NRC, as well as industry-based reforms, proved effective, forcing the nuclear power industry to significantly improve its power plant operations. As a result of these combined reform efforts, the median number of emergency scrams per nuclear reactor declined from approximately seven emergency shutdowns annually in 1980 to nearly zero shutdowns annually by 2001. This indicates that at least half of all power plants that reported data experienced zero emergency shutdowns in 2001.[79] As such, the reforms created by the NRC following the Three Mile Island accident helped facilitate the transformation of the nuclear power industry into a safer and more reliable endeavor, while also allowing nuclear power to remain a prominent source of energy for the United States.[80] As such, the study of the reforms mentioned above allows one to understand

the development of the nuclear power industry in the United States.

The Three Mile Island nuclear accident represents a crucial turning point in the history of nuclear power in the United States. Caused by a combination of mechanical breakdowns and human error, the failure of the power plant's reactor core coolant system highlighted several major flaws in the regulation of nuclear utilities. This incident demonstrated that reactor operators received insufficient training and possessed few of the skills necessary to prevent or manage a major accident. This, combined with confusing control interfaces, prevented the operators of Three Mile Island from accurately diagnosing the source of the reactor's problems. The combination of these two factors led to significant calls for reform. Initial reforms attempted to alter the NRC itself. Focusing primarily on bolstering the authority of the organization, new policies granted increased authority to the NRC by strengthening the powers of its executive director and commission chairman. These policies also granted the NRC increased authority over the nuclear power industry by allowing it to place federal inspectors in all nuclear power plants. Reform initiatives also attempted to stabilize the nuclear power industry by forcing it to adopt stringent safety protocols intended to protect the general public from the harmful effects of a possible nuclear accident. However, the reforms adopted by the NRC also promoted, to a lesser degree, the development of the nuclear power industry by removing safety hearings from the reactor licensing process. Despite this, the Three Mile Island accident forced the Nuclear Regulatory Commission to adopt and implement new standards intended primarily to promote safety rather than the growth of nuclear power.

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[2] Kenneth L. Miller, "The Nuclear Reactor Accident at Three Mile Island," *RadioGraphics* 14, no.1 (January 1994): 215, http://highwire.stanford.edu.

[3] Bonnie A. Osif, Anthony J. Baratta, and Thomas W Conkling, *TMI 25 Years Later: Three Mile Island Nuclear Power Plant Accident and its Impact* (University Park: The Pennsylvania State University Press, 2004), 76-77; James Coates, "Commission's Grim Forecast: It Could Happen Again," *Chicago Tribune*, October 31, 1979, http://proquest.com.

[4] Bonnie A.Osif, Anthony J. Baratta and Thomas W. Conkling. *TMI 25 Years Later;* J. Samuel Walker, *Three Mile Island: A Nuclear Crisis in Historical Perspective* (Berkeley: University of California Press, 2004).

[5] James R. Temples, "The Nuclear Regulatory Commission and the Politics of Regulatory Reform: Since Three Mile Island," *Public Administration Review* 42, no.4 (July-August 1982): http://www.jstor.org.

[6] Post-accident reports estimated that residents around Three Mile Island were exposed to 1.5 millirems of radioactive material. This exposure represents a relatively small dose compared to naturally occurring sources of radiation. Sources, such as cosmic radiation, may expose one to nearly 116 millirems of radiation annually. Osif, Baratta, and Conkling, *TMI 25 Years Later*, 66, 85.

[7] The most significant of these organizations arose with the creation of the Institute of Nuclear Power Operations (INPO) in December, 1979. Created as a cooperative enterprise through an agreement signed by the CEOs of every major nuclear power company, the INPO represented an attempt to develop and implement a set of operational and safety standards for nuclear power plants independently of federal authorities. The organization proved highly successful and remains in existence today. However, the INPO remains a highly secretive organization, well known for its refusal to release information regarding its findings or activities to the general public. However, the actions of this organization lie beyond the scope of this article and will not be covered in depth. See Joseph V. Rees, *Hostages of Each Other: The Transformation of Nuclear Safety Since Three Mile Island* (Chicago: University of Chicago Press, 1994).

[8] James Mahaffey, *Atomic Awakening*: *A New Look at the History and Future of Nuclear Power* (New York: Pegasus Books, 2009), 206.

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[11] Osif, Baratta, and Conkling, *TMI: 25 Years Later*, 78-79

[12] Osif, Baratta, and Conkling, *TMI 25 Years Later*, 76-77.

[13] Richard Curtis, Elizabeth Hogan, and Shel Horowitz, *Nuclear Lessons: An Examination of Nuclear Power's Safety, Economic, and Political Record* (Harrisburg, PA: Stackpole Books, 1980), 210.

[14] However, while these turn-key reactor deals facilitated the growth of the nuclear power industry, they also resulted in severe financial loss for both GE and Westinghouse. Both companies lost a combined $1 billion between 1964 and 1967. Peter Pringle and James Spigelman, *The Nuclear Barons* (New York:, Holt, Rinehart, and Winston, 1981), 265.

[15] Mahaffey, *Atomic Awakening*, 303.

[16] It should be noted that 1 megawatt is equivalent to 1 million watts of electricity. 1 megawatt can also power 1000 homes for roughly one hour. Scott Fenn, *The Nuclear Power Debate: Issues and Choices* (New York: Praeger Publishers, 1981), 77.

[17] Federal Power Commission, *Statistics of Electric Utilities in the United States: 1964* (Washington, DC: Government Printing Office, 1964), VI.

[18] Fenn, *The Nuclear Power Debate*, 58.

[19] William Sweet, *The Nuclear Age: Atomic Energy, Proliferation, and the Arms Race* (Washington, DC: Congressional Quarterly Inc., 1988), 47.

[20] Pringle and Spigelman, *The Nuclear Barons*, 400.

[21] Pringle and Spigelman, *The Nuclear Barons*, 403.

[22] Sweet, *The Nuclear Age*, 54.

[23] Sweet, *The Nuclear Age*, 17.

[24]Gary L. Downey, "Reproducing Cultural Identity in Negotiating Nuclear Power: The Union of Concerned Scientists and Emergency Core Cooling," *Social Studies of Science* 18, no. 2, (May 1988): 235-236, 251, www.jstor.com.

[25] The concerns of the UCS were later validated by the Three Mile Island accident. Downey, "Reproducing Cultural Identity in Negotiating Nuclear Power," 251.

[26] Pringle and Spigelman, *The Nuclear Barons*, 373.

[27] John Kifner, "2000 Occupy Nuclear Plant Site in New Hampshire, Vow To Stay," *New York Times*, May 1, 1977, http://proquest.com.

[28] It should be noted that a kilowatt-hour refers to the generation of one kilowatt of energy per one hour of electrical production. A kilowatt is equivalent to 1000 watts of electricity. Federal Power Commission, *Statistics of Privately Owned Electric Utilities in the United States: 1974* (Washington, DC: US Government Printing Office, 1974), XI.

[29] Cole, oil, and gas-based forms of electrical production generated 1.229 trillion kilowatt-hours of electricity in 1974. Federal Power Commission, *Statistics of Privately Owned Electrical Utilities*, XI.

[30] Michael T. Hatch, "Nuclear Power and Post Industrial Politics in the West," in *Governing the Atom: The Politics of Risk*, edited by John Byrne and Steven M. Hoffman (New Brunswick, NJ: Transaction Publishers, 1996), 205.

[31] Subcommittee on Energy Research and Production of the Committee on Technology, *1982 Department of Energy Authorization*, 97th cong., 1st sess., 1981, 3.

[32] Subcommittee on Energy Research and Production of the Committee on Technology, *1982 Department of Energy Authorization*, 44.

[33] Subcommittee on Energy Research and Production of the Committee on Technology, *1982 Department of Energy Authorization*, 44.

[34] American Enterprise Institute for Public Policy Research, *Nuclear Energy: A Reassessment* (Washington, DC: American Enterprise Institute for Public Policy Research, 1980), 215.

[35] Osif, Baratta, and Conkling, *TMI 25 Years Later*, 80; "Energy Reorganization Act," *NRC: Our Governing Legislation*, www.NRC.org.

[36] Walker, *Three Mile Island*, 37.

[37] Subcommittee on Nuclear Regulation for the Senate Committee on Environment & Public Works, *Nuclear Accident and Recovery at Three Mile Island: A Special Investigation*, 16th Cong., 2nd sess., 1980, 66.

[38] Subcommittee on Nuclear Regulation for the Senate Committee on Environment & Public Works, *A Special Investigation*, 66.

[39] Subcommittee on Nuclear Regulation for the Senate Committee on Environment & Public Works, *A Special Investigation,* 71.

[40] Walker, *Three Mile Island,* 75.

[41] John J. Goldman, "Nuclear Power Industry Learns Lessons of Failure," *Los Angeles Times*, May 23, 1983, www.proquest.com.

[42] Rees, *Hostages of Each Other*, 11.

[43]More than double the average annual exposure to radiation experienced by an individual, the levels of radiation within the TMI plant proved high enough to cause severe illness and possible death to anyone exposed. Walker, *Three Mile Island*, 85.

[44]American Enterprise Institute for Public Policy Research, *Nuclear Energy: A Reassessment,* 10.

[45] Walker, *Three Mile Island*, 76-77; Nuclear Regulatory Commission Special Inquiry Group, *Three Mile Island, A report to the Commissioners and to the Public* (Washington DC: Government Printing Office, 1980), 14.

[46] Osif, Baratta, and Conkling, *TMI 25 Years Later*, 81.

[47] President's Commission on the Accident at Three Mile Island, *Report of the U.S. President's Commission on the Accident at Three Mile Island-The Legacy of Three Mile Island: The Need for Change* (New York: Pergamon Press, 1979), 7.

[48] Subcommittee on Energy Research and Production of the Committee on Science and Technology, *Oversight: Kemeny Commission Findings*, 96th Cong., 1st sess., November 4, 1979, 6-7.

[49] President's Commission of the Accident at Three Mile Island, *The Legacy of Three Mile Island*, 9.

[50] President's Commission on the Accident at Three Mile Island, *The Legacy of Three Mile Island*, 61.

[51] Temples, *Politics of Regulatory Reform*, 315

[52] Rees, *Hostages of Each Other*, 33.

[53] Subcommittee on Oversight and Investigations of the Committee on Interior and Insular Affairs, *Nuclear Regulatory Commission's Inspections Process: Hayward-Tyler Pump Company*, 97th Cong., 2nd sess., April 6, 1982, 12-13.

[54] Scott Fenn, *The Nuclear Power Debate*, 59.

[55] Richard T. Sylves, "Carter Nuclear Licensing Reform versus Three Mile Island," *Publius* 10, no. 1 (Winter, 1980): 76, http://www.jstor.org.

[56] Subcommittee of the Committee on Government Operations, *Nuclear Safety: Is NRC Enforcement Working?,* 97th Cong., 1st sess., December 1, 1981, 3.

[57] Subcommittee of the Committee on Government Operations, *Is NRC Enforcement Working*, 3.

[58] David Okrent, "The Safety Goals of the U.S. Nuclear Regulatory Commission," *Science* 236, no. 4799 (April 17, 1987), 236, http://jstor.com.

[59] Okrent, "Safety Goals," 236.

[60] Okrent, "Safety Goals," 297.

[61] Okrent, "Safety Goals," 298.

[62] Baruch Fischhoff, "'Acceptable Risk': The Case of Nuclear Power," *Journal of Policy Analysis and Management* 2, no. 4 (Summer 1983): 560, http://jstor.com.

[63] Fischhoff, *The Case of Nuclear Power*, 560.

[64] A person-rem is a unit of measurement quantifying one's level of exposure to radiation. Fischhoff, *The Case of Nuclear Power*, 561.

[65] Sylves, *Carter Nuclear Licensing Reform*, 73, 76; Casey Burko, "Atom Power Faces Crises in Licensing," *Chicago Tribune*, December 20, 1979, http://proquest.com.

[66] Subcommittee of the Committee on Government Operations, *Emergency Planning Around U.S. Nuclear Power Plants: Nuclear Regulatory Commission Oversight*, 96th Con., 1st sess., 1979, 379.

[67] Subcommittee on Energy and the Environment of the Committee Interior and Insular Affairs, *Nuclear Regulatory Commission Operating Licensing Process,* 97th cong., 1st sess., April 1, 1981, 68-69.

[68] Subcommittee on Energy and the Environment, *Operating Licensing Process*, 9.

[69] Osif, Baratta, and Conkling, *TMI 25 Years Later*, 86.

[70] Subcommittee of the Committee on Government Operations, *NRC Licensing Speedup*, 13-14.

[71] Subcommittee on Energy and The Environment of the Committee on Interior and Insular Affairs, *Nuclear Regulatory Commission Operating Licensing Process,* 8.

[72] Third Party Intervenors were considered any member of the general public who filed a challenge against either an NRC regulation or proposed construction of a nuclear power plant. Subcommittee of the Committee on Government Operations, *NRC Oversight: Limitations on Intervenors in Licensing Proceedings*, 96th cong., 2nd sess., 1980, 2.

[73] Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs, *Operating Licensing Process*, 9.

[74] Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works, *Nuclear Regulatory Reform*, 99th Cong., 1st sess., 1985, 202-203.

[75] Subcommittee on Nuclear Regulation, *Nuclear Regulatory Reform*, 205.

[76] Subcommittee in Nuclear Regulation, *Nuclear Regulatory Reform*, 205.

[77] The term "scram" refers to an emergency shutdown of a nuclear reactor. These shutdowns utilize a series of control rods, usually consisting of various types of metals capable of absorbing neutrons, which drop into a reactor core to help slow or stop a nuclear reaction.

[78] Rees, *Hostages of Each Other*, 186.

[79] Osif, Baratta, and Conkling, *TMI 25 Years Later*, 90.

[80] By 2004, over 100 nuclear power plants generated 22% of America's electricity. Osif, Baratta, and Conkling, *TMI 25 Years Later,* 86.