After Fukushima: Nuclear Power in the United States

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Introduction

Like Three Mile Island and Chernobyl, the Fukushima nuclear disaster prompted a global reexamination of nuclear power. Almost immediately, the EU announced plans to test all 143 reactors in its 27 member states (Dempsey 2011; Dempsey and Ewing 2011). Days after the accident, Germany closed eight of its oldest reactors; and later announced that the rest would be shut down by 2022. In March China, which has ambitious nuclear construction plans, announced it would issue no new permits until it upgraded its safety standards. Switzerland, which had been planning three new reactors, quickly halted the licensing process and in May canceled the projects completely. In June, voters in Italy overwhelmingly rejected a government plan to restart its nuclear program (King 2011). As a result of these decisions, the International Energy Agency reduced by half its estimate of new nuclear installations over the next twenty five years, citing greater public scrutiny and the prospects of enhanced safety requirements and higher construction costs (Morales 2011).

Nuclear prospects even dimmed a bit in France, which gets more than 75 percent of its electricity from nuclear power. The Socialist victory in France's 2012 elections ushered in a new government that has vowed to reduce the nation's reliance on nuclear power. In Japan, the nation's final operating reactor was taken offline in May 2012 for required maintenance, the first time in forty years that the nation has been without nuclear generated electricity (Fackler 2012).

Although that situation is only temporary, Japan had previously announced plans to curtail its use of nuclear power and to transition to renewables and greater energy efficiency (Schneider, Froggatt, and Thomas 2011).

In Great Britain and the United States, on the other hand, officials seemed determined to not allow the Fukushima accidents to derail their nuclear programs. Indeed, one set of analysts described the U.S. political system as "stunningly impervious" to the concerns expressed in other countries (Schneider, Froggatt and Thomas 2011, 66). Just one month after the meltdowns, Martin Virgilio, NRC Deputy Executive Director for Reactor and Preparedness Programs, testified to Congress that a "review of the information combined with our ongoing inspections, licensing, and oversight allows us to say with confidence that the U.S. plants continue to operate safely" (Quoted in U.S. Congress 2011a, 7). Perhaps more telling, in early 2012 the U.S. Nuclear Regulatory Commission (NRC) approved licenses for four new reactors even before completing its Fukushima safety reviews.

This approach is entirely consistent with the agency's history, as it has repeatedly postponed action on known safety issues and failed to consistently enforce its own rules. For example, a review of safety at U.S. nuclear plants by the Union of Concerned Scientists (UCS) concluded that nearly half the plants do not comply with fire regulations first adopted in 1980 and then amended in 2004, and that 27 operate without adequate protection against earthquakes. Furthermore, eight plants have inadequate protection against both fire and earthquake (Lochbaum 2012). The 1979 accident at Three Mile Island (TMI), the 1986 Chernobyl accident, and the September 11, 2011 terrorist attacks raised doubts about the safety of commercial nuclear power, and each incident provided opportunities for the NRC to take decisive steps to

enhance plant safety. The evidence suggests, however, that the agency enacted some changes, but generally acceded to industry preferences to avoid more fundamental overhauls. There are troubling signs that the same cycle is playing out with respect to Fukushima.

The U.S. Nuclear Regulatory Commission was quick to conclude that U.S. reactors were safe to operate even before results from the Fukushima reviews were complete. There is also evidence that several of the commissioners and senior staff worked to delay the report of the Near Term Task Force report on Fukushima, to water down its recommendations, and to delay its public release. At the same time, the agency was moving ahead with license extensions for existing reactors and approving license for new reactors. NRC documents also reveal that officials were very sensitive to diverting resources from the licensing process to the Fukushima safety reviews.

This essay reviews commercial nuclear power regulation in the United States in the aftermath of the Fukushima accidents. We begin with an overview of the status of nuclear power today, and then consider the Nuclear Regulatory Commission's (NRC) procedural and substantive responses to the events in Japan. We then proceed to show that the agency's response to Fukushima is consistent with how it has handled other safety related issues in recent years.

Commercial Nuclear Power in the U.S.

There are currently 104 reactors in operation at 65 sites in the United States; 69 are pressurized water reactors (PWR), and 35 are boiling water reactors (BWR) similar to those at Fukushima (U.S. NRC 2012b). Nuclear power provides just under 20 percent of U.S. electricity, a share that is projected to decline slightly over the next twenty five years (U.S. Department of Energy, Energy Information Administration 2012). The average reactor, originally licensed for

forty years, has been in operation for thirty years; 71 reactors, however, have received 20 year license extensions and the NRC is currently reviewing extensions for another thirteen (World Nuclear Association 2012).

In the few years preceding the Fukushima meltdowns the U.S. nuclear power industry had seen its fortunes quickly rise and fall. In September 2007, NRG Energy filed the first full application to build a reactor since 1979, and within a year the NRC had received 16 applications for a total of 24 reactors (Davis 2011). Industry supporters touted the rush of applications as evidence of a long awaited "nuclear renaissance." But it was not to be--natural gas prices soon plummeted, the economy cratered, and electricity demand declined. The NRC received just one new reactor application in 2009 and none thereafter. Exactly how many of these projects will actually be built thus remains highly uncertain, and is dependent on many factors, including fossil fuel prices, federal incentives, climate change policy and, of course, construction and financing costs which will almost certainly spike after Fukushima (Cooper 2011b; Davis 2011). Just one month after Fukushima NRG pulled the plug on its two South Texas reactors and wrote off its $331 million investment (Wald 2011). The company's CEO said that the meltdowns had "introduced multiple uncertainties around new nuclear development in the United States" and had raised doubts that the Texas reactors "can be successfully developed in a timely fashion." Similarly, John Rowe, the CEO of Exelon, a nuclear utility, said "new nuclear plans are not economic investments with today's natural gas forecasts" (Schneider, Froggatt, and Thomas 2011, 67).

Nonetheless, in February 2012, less than one year after Fukushima, the NRC voted 4-1 to issue a license for two reactors at the Vogtle project in Georgia. This was the first license issued

by the agency since 1978. The Commission did not require that plant owners implement any post-Fukushima safety upgrades, despite arguments from the agency's staff that the containment of the new reactor design was brittle and could break in an earthquake or if struck by a commercial aircraft. The first Vogtle reactor is scheduled to go online in 2016, with the second in 2017. Just one month later the NRC also approved (by a similar 4-1 margin) a license for two reactors at the Virgil C. Summer plant in South Carolina. The utility hopes to begin operation in 2017, with the second unit opening the following year.

In both instances the dissenting vote was cast by the NRC's chairman, Gregory Jaczko, who argued that the plant's owners should be required to implement additional safety requirements adopted after Fukushima. Jaczko, a former staffer to Senate Majority Leader Harry Reid (D-NV), was appointed to the NRC by President George W. Bush and then elevated to the chairmanship in 2009 by President Obama.[1] Jaczko, who recently announced his resignation, has been criticized by Republican officials and the nuclear industry for being overly aggressive in pushing for enhanced safety rules, and for his role in ending the agency's review of the proposed siting of a high level waste repository in Yucca Mountain, Nevada. After the other commissioner's objected to his handling of the Fukushima disaster, claiming that he had failed to keep them adequately informed, the Commission's internal disagreements were thrust into the open during a highly contentious congressional hearing at which the others accused him of withholding information on a variety of matters and of being abusive to agency staff (Restuccia 2011). The agency's inspector general launched an investigation into the charges; the results are pending.

The NRC's Response to Fukushima

This section examines the U.S. Nuclear Regulatory Commission's response to the Fukushima meltdowns. Although it is too early to gauge with any certainty the accident's long-term effects on the nuclear industry, one thing is clear—the NRC, and its regulatory approach, have once again been thrust into the spotlight, as they were following Three Mile Island and the terrorist attacks of September 11th. Like those earlier events, Fukushima revealed serious lapses in NRC rules and reactor design. The key question is whether the agency will resolve those problems, or continue with business as usual.

The problems at Fukushima began with a massive earthquake off the coast of Japan, which then triggered a tsunami that inundated the plant, knocking out off-site power as well as the on-site emergency diesel generators and batteries that are supposed to provide power in the event of an accident. The result was a complete loss of power at the facility—a situation known as a station blackout. With no power, operators were unable to cool the cores of those reactors that had been operating as well as some of the spent fuel pools. As a result, three of the reactors suffered meltdowns, and the buildup of hydrogen that resulted in the containment buildings lead to explosions and the release of radioactivity.

Station blackouts are considered to be "beyond-design-basis" events—that is, events that are possible but not fully considered in the design process because they are deemed too unlikely. A "design-basis" accident, in contrast, is one that a reactor must be designed for and built to withstand. NRC rules are focused on design basis accidents and are less stringent than those for severe accidents; the NRC has addressed severe accidents on an ad hoc basis, but most of the measures designed to prevent and mitigate them are voluntary. Moreover, the design basis for U.S. reactors does not envision accidents affecting multiple units, as in Fukushima.

The Atomic Energy Commission, the NRC's predecessor, had proposed rules on station blackouts as early as 1974, but the nuclear industry opposed them, arguing that station blackouts were impossible. It was not until 1988 that the NRC issued the first rules for coping with station blackouts. These rules required plant owners to evaluate their facilities for vulnerabilities to "beyond-design-basis" events, and to have a strategy for coping with blackouts of up to 16 hours, but the agency ignored the possibility that certain events, such as severe earthquakes or tornadoes, could disrupt a plant's surrounding infrastructure for a much longer period (Union of Concerned Scientists 2011). At the same time, though, the new rules did not require actual upgrades to address any of the problems that were found during the evaluation; NRC inspectors cannot cite an owner for a violation if they find that a voluntary safety measure is ineffective or has been removed. As a result, some plant owners implemented measures to upgrade protections, while others did nothing. The NRC eventually required licensees to develop measures to "cope" with station blackouts for a limited period, but did not require that the equipment installed to cope with them be classified as "safety-related." As a result, the equipment does not have to meet the agency's highest quality assurance standards (Lochbaum and Lyman 2012).

The NRC's initial response to the unfolding events in Japan was to significantly expand staffing levels at its emergency response center in order to field requests for information from the media, public, and Congress. In the aftermath of the accident at Three Mile Island in 1979, the chairman of the NRC was given the responsibility of acting as the agency's spokesperson and principal executive officer, in an attempt to clarify the chain of command and communication structures. Acting in this capacity, NRC Chair Gregory Jaczko enraged the nuclear industry and its supporters when he recommended, a few days into the accident, that U.S. citizens within a 50

mile radius of the Fukushima plant evacuate. Jazcko's announcement was controversial because the emergency planning zone for U.S. reactors is only 10 miles, and industry supporters believed that the 50 mile recommendation implicitly called into question the adequacy of the U.S. policy. On March 17th, six days after the earthquake and tsunami, Jaczko also called for the creation of a senior NRC task force on Fukushima to provide recommendations to the Commission, and suggested that the commissioners meet on March 21 to discuss the details. In a March 17 email to another commissioner, NRC commissioner William Magwood wrote that Jaczko's suggestions made it clear that the Chairman wanted to keep the Commission "out of it" (U.S. Congress 2011b). This was an early sign of internal discord within the NRC, with other commissioners believing that Jaczko was withholding information from them and agency staff.

On March 23, the NRC announced the creation of a six member Near-Term Task Force (NTTF) on the Fukushima accident. The Task Force was given 90 days to review the accident and recommend measures to enhance safety at U.S. plants. The Task Force was directed to "evaluate all technical and policy issues related to the event to identify potential research, generic issues, changes to the reactor oversight process, rulemakings, and adjustments to the regulatory framework that should be conducted by the NRC," all of which was to be made public (U.S. Congress 2011a , 22). In accordance with Commission direction, the NRC's Fukushima review actions are being led by a steering committee of senior NRC managers. The agency later established the Japan Lessons Learned Project Directorate, comprised of more than twenty full time employees, to oversee implementation of new safety measures and procedures (U.S. Nuclear Regulatory Commission 2012d).

The Commission's second major decision was to order two rounds of safety inspections at the nation's operating reactors, although there were indications that the agency also sought to limit their scope. For example, the NRC initially gave inspectors just 40 hours to perform each inspection, and 50-60 hours for plants with multiple units. In contrast, the Institute for Nuclear Power Operations (INPO), the industry's internal watchdog, devoted hundreds of man-hours to inspecting each plant. More telling, perhaps, is that the NRC inspectors were initially told to limit their inspections to the adequacy of safety measures needed to respond to design basis events—only events that had already been assessed by the agency and for which requirements had already been implemented. In other words, they were instructed not to consider events like Fukushima which, as noted above, was a "beyond-design basis" event. After complaints from its inspectors, the guidance was changed to allow such consideration, but the inspectors were told not to record any of their "beyond-design basis" observations in documents that would be made public as part of the Commission's reviews. Instead, those findings would be placed in a private NRC database (U.S. Congress 2011a). NRC inspectors were also instructed not to include items in their reports that licensees had already identified in their own reviews; since INPO inspectors had already concluded their reviews, none of those items were to be included in NRC inspection reports.

Despite these limits, the post Fukushima inspections revealed problems with some of the measures adopted in the aftermath of the 9/11 attacks, including the severe-accident management guidelines (SAMGs) that were voluntarily developed by utilities. In an effort to cope with station blackouts caused by attacks on nuclear plants, the NRC had required plant owners to install "B.5.b." equipment, such as additional pumps, valves and other equipment, to mitigate fires and explosions caused by attacks. The first set of inspections examined each plant's ability

to cope with station blackouts and severe natural disasters while still ensuring adequate cooling of reactor cores and spent fuel pools. They showed that existing capabilities might be suspect; some of the B.5.b. equipment was housed within buildings vulnerable to earthquakes and tornadoes, and in some locations the inventory of equipment was insufficient to handle problems in multiple reactors at one site, as in Fukushima. Such findings were not surprising because the NRC had never required that the additional equipment be protected against such events. Nor did the NRC rules on station blackout require that owners assume that multiple plants would be affected or that they would occur concurrently with another event—like an earthquake. The second set of inspections investigated the SAMGs, which revealed that the emergency response procedures to be used at U.S. reactors were often out of date and that plant operators were often not trained on how to implement them. According to the Union of Concerned Scientists, these findings were not surprising, because these were voluntary measures and therefore did not have to meet any regulatory standards (Lochbaum and Lyman 2012).

The Report of the Near-Term Task Force

According to some reports, several NRC commissioners and senior staff worked to shape the report of the Near-Term Task Force and to delay its release to Congress and the public (U.S. Congress 2011b). On June 29, 2011, the NRC commissioners received a draft of the NTTF report on Fukushima, along with a proposal to release the report to the NRC and Congress on July 12, and to the public on July 13. On July 4, Commissioner Magwood's staff recommended a vote to delay the public release by ten days. Several days later, the NRC staff wrote to the commissioners recommending the original July 13 release date, and on July 12, after considering

concerns that a delayed public release would lead to concerns that the NRC was trying to massage the results, the commissioners accepted that recommendation (U.S. Congress 2011b).

Bill Borchardt, NRC Executive Director of Operations, took the unusual step of attaching a five page memo of his own views to the report so that commissioners would be asked to vote on his views in addition to the report itself. Borchardt did so despite an earlier NRC vote that the report be presented without additional materials. Borchardt's memo emphasized that U.S. plants were unlikely to experience the same problems as those in Japan, and also recommended that "before deciding on the path forward and the specific recommendations in the Task Force's report, the Commission may wish to solicit external stakeholder input", noting that there would be a benefit to developing alignment on the objectives, approaches and schedules with those of external stakeholders for implementing safety improvements. Borchardt's memo was removed from the report on July 12, prompting him to tell Chairman Jaczko that he would object publicly to the action. Some NRC commissioners also objected to the agency's press release on the report, calling it "irresponsible" (U.S. Congress 2011b, 14).

The Near-Term Task Force issued its report on July 12, 2011, concluding that "continued operation and continued licensing activities do not pose an imminent risk to public health and safety" (U.S. NRC 2011, vii). At the same time, though, the Task Force issued twelve recommendations, some with multiple parts, for enhancing reactor safety (See Appendix 1). The implementation strategy was patterned after those the NRC used in response to the 9/11 attacks. The agency would issue orders to plant owners for safety upgrades in the short term, to be followed by rule making to formalize those upgrades as well as to implement any longer-term upgrades to follow. The NRC may impose new safety requirements through orders or rule

making; rulemaking requires the agency to solicit and review comments from the public and stakeholders. Orders are faster because there is no need to solicit comments, but for changes that affect all plants, the NRC cannot simply issue orders as a substitute for rulemaking procedures that are required by law (Lochbaum and Lyman 2012, 10).

The NTTF recommendations fell into five categories: clarifying the regulatory framework, ensuring protection, enhancing mitigation, strengthening emergency preparedness, and improving the efficiency of NRC programs. The first and most important recommendation, because it provided the foundation for many of the others, was that the NRC should clarify its regulatory requirements governing beyond design-basis accidents such as the one at Fukushima. More precisely, the Task Force's first recommendation was "establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations" (U.S. NRC 2011, ix). As noted previously, NRC rules require reactors to be designed to handle only certain types of accidents—so called design basis accidents, but not most beyond- design-basis accidents such as Fukushima. As a result, the agency's rules for severe accidents are a patchwork, applying to some types of beyond-design-basis accidents but not others. To remedy this shortcoming, the Task Force also recommended that the agency strengthen station blackout mitigation capabilities at all operating reactors and new reactors for both design-basis and beyond-design basis events. Other Task Force recommendations included requiring licensees to reevaluate and upgrade the design-basis seismic and flooding protections for each reactor, and evaluating possible changes in capability of preventing or mitigating seismically induced fires and floods.

The Task Force also said that the NRC should require hardened vent designs in boiling water reactors with containments similar to those in Fukushima. Vents are supposed to reduce heat and pressure within the containment building during an accident. In the first days after the accident, the NRC had initially suggested that U.S. reactors had such vents but that those in Japan did not. This was untrue—the Fukushima reactors did have hardened vents, but they failed to operate because they required electricity (Lochbaum and Lyman 2012). Incredibly, however, NRC rules do not require that such vents be operable; nor does the agency require that spent fuel pools have vents. Furthermore, many U.S. systems also require electricity to operate the vents, which was precisely the problem in Japan (U.S. Congress 2011a).

The NTTF also recommended that emergency plans address prolonged station blackout and events at multiple rectors. After 9/11, the NRC required owners to install equipment such as portable diesel fuel pumps and generators to protect plants from prolonged station blackouts caused by aircraft attacks. But because these attacks were considered to be beyond-design-basis events the NRC did not also require that the equipment meet its highest quality standards or that it be protected from earthquakes, flooding, or other natural disasters. Subsequent inspections have confirmed that much of the equipment would not survive earthquakes or floods (Lochbaum and Lyman 2012).

The NTTF further recommended requiring enhanced spent fuel cooling capability and instrumentation of the spent fuel pool so that operators could better monitor conditions (U.S. NRC 2011, ix). As in Fukushima, most U.S. reactors lack instrumentation that would allow operators in the control room to remotely monitor water levels in spent fuel pools. This is critical because if the spent fuel pools lose water or if the cooling system is interrupted, the spent

fuel could overheat and its cladding could break open, releasing radioactivity. Because spent fuel pools are located outside the primary containment structure that surrounds the reactor vessel, any radiation releases are more likely to reach the outside environment (Union of Concerned Scientists 2011).

NRC Actions on the NTTF Report

The NRC staff and commissioners spent the next several months evaluating the Task Force report and deciding how to proceed. According to a report by the staff of Congressman Ed Markey (D-MA), ranking member of the House Energy Committee, senior NRC staff and up to four NRC commissioners sought to delay, weaken, or defeat the implementation of key NTTF recommendations (U.S. Congress 2011a). As early as July 15, three days after the NTTF issued its report, commissioners Magwood and Ostendorff exchanged emails expressing concern about Chairman Jaczko's plan to vote on Task Force recommendations within 90 days. Magwood's chief of staff also suggested that the commission vote to send the entire report back to staff and to not support any of the meetings Jaczko had proposed. On July 17th Ostendorff's chief of staff emailed his peers to suggest that any votes be postponed until the views of additional NRC staff were understood, and until the Commission had voted on a charter for a longer-term staff review of Fukishima. Several of the other chiefs of staff indicated that there was support for referring the Task Force recommendations to a second group of NRC staff charged with taking a longer term view of the accident (U.S. Congress 2011b).

In late July the commissioners submitted their votes on the Task Force report. Jaczko voted in support of completing all 12 recommendations within five years and proposed that the Commission vote on whether to implement them within 90 days. The other commissioners did

not agree, with Magwood and Svinicki voting to require a new group of staff to submit plans on how to evaluate the NTTF recommendations and detailing how they would obtain stakeholder input. The plans on how to evaluate the recommendations would have to be voted on by the NRC before any of the technical evaluation could begin (U.S. Congress 2011b).

On August 19 the NRC finally obtained majority support for a plan that directed the NRC staff to provide the Commission with three papers that would form the basis of the commission's future decisions. The first would be submitted within 21 days and would specify which NTTF recommendations could be implemented in whole or in part without delay. The second paper would be due within 45 days and would prioritize the recommendations and identify all of the necessary regulatory actions and implementation challenges. The third paper would be due within 18 months and would offer suggestions on how to proceed with the NTTF's first recommendation—that the agency replace the patchwork of safety regulations with a logical, systematic, and coherent regulatory framework. In making this decision, the Commission directed the staff to consider this recommendation separately from the others, and only within 18 months, effectively moving it to the back of the line (U.S. Congress 2011b; Lochbaum and Lyman 2012). The NTTF had justified Recommendation 1 by saying that the Commission has "come to rely on design-basis requirements and a patchwork of beyond-design-basis requirements and voluntary initiatives for maintaining safety." The Task Force's specific recommendation was that the NRC should establish "a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations" (U.S. NRC 2011). NRC senior managers apparently interpreted that to mean that the agency's current regulatory framework was none of those things, and objected.

The UCS later concluded that the agency's decision to relegate the Task Force's first and most important priority to later was a "major flaw" (Lochbaum and Lyman 2012, 2).

While these internal discussions were proceeding, the NRC was also holding public meetings to solicit input from stakeholders. The nuclear industry was invited to participate along with other groups, including the Union of Concerned Scientists. The NRC staff's 45 day paper identified six items that had been raised by external stakeholders, including UCS proposals that the NRC require larger evacuation zones, wider distribution of potassium iodide, and a faster transfer of spent fuel to dry cask storage (Lochbaum and Lyman 2012). On September 2, the Nuclear Energy Institute, the industry's trade association, wrote the NRC staff to outline the industry's proposed near-term actions for addressing the Fukushima accidents. The voluntary program, known as FLEX, was based on the notion that expanding prevention of core and spent fuel damage and ensuring containment function during an extended station blackout should be the focus of reforms. Under the plan, the B.5.b equipment required after 9/11 (diesel driven pumps, air driven pumps for flood equipment, sump pumps, hoses, electrical generators, cables, and fire trucks) would be stored at diverse locations and protected to ensure that it could be used in the case of natural disasters (Nuclear Energy Institute 2012b). The industry plan would not require that the equipment be hardened, or classified as "safety-related," which would be more expensive, but would instead disperse it to several locations on and off-site, in the hope that enough would survive after a disaster. The NEI argued that if the FLEX plan were implemented it would eliminate the need for most of the Near-Term Task Force recommendations. The industry has been buying equipment before the NRC has developed any guidelines, which could make it difficult for the agency to later require industry to replace with higher quality, and more

expensive equipment. The NRC is currently proposing that licensees provide "reasonable protection" for emergency equipment, but has not yet defined what term means.

One week later the NRC staff submitted its 21 day review of the Task Force report, saying that all of the recommendations "if implemented, would enhance safety and the staff agrees with moving forward with each of these recommendations." The staff also prioritized the Task Force recommendations, placing them into three different tiers. Tier 1 items were expected to be completed mostly by means of orders issued to plant owners before the Fukushima anniversary. Tier 2 items would be addressed through rulemaking within five years of the accident, while Tier 3 items were put off until September 2012. The staff, however, did not express a sense of urgency, as licensees were given up to five year to fully implement the Tier 1 items (Lochbaum and Lyman 2012).

In its second paper to the Commission, the staff identified six possible recommendations arising from its meetings with external stakeholders. These included possible filtration of hardened containment vents to reduce the risk of a release of radioactivity in the event of an accident, that instrumentation for seismic monitoring be upgraded, as well as three UCS proposals that the NRC consider expanding the emergency planning zone around reactors, the pre-staging of potassium iodide beyond the current ten mile emergency planning radius, and that the transfer of spent fuel from pools to dry cask storage be accelerated (Lochbaum and Lyman 2012). The NRC eventually decided that it would not consider expanding emergency zones as part of the agency's post-Fukushima review; the issue would instead be handled separately.

The NRC staff was also considering requiring filters for the vents, which would relieve the pressures inside a dangerously pressurized containment building by releasing some of its

radioactive gases to the atmosphere through a large filter system. The filters would trap the most dangerous radioactive isotopes before they could escape to the environment. Filters have been required in Europe since late 1980s, and have since been mandated in Japan and Romania. The NEI opposed the requirement, saying that the issue was being hastily considered and that the NRC should instead consider other means of controlling radioactive releases (Zeller 2012). Industry officials said that other safety steps, such as additional pumps and valves, could result in a level of safety similar to that of filtered vents, but critics have argued that the industry is simply hoping to avoid more stringent rules and more expensive safety grade equipment (Wingfield 2012).

Both the NTTF and the NRC staff reviewing its report had concluded that the various recommendations for upgrades to existing plants were "necessary to ensure that the facility provides adequate protection to the health and safety of the public." The wording is significant because under the agency's longstanding backfit rule, new regulations for existing reactors are not required to conduct a cost-benefit analysis to justify their implementation when the new requirements are deemed necessary to provide "adequate protection" to the public. In early October, a majority of the NRC rejected the staff position, thereby creating the possibility that the nuclear industry could delay implementing new requirements by calling for a cost-benefit analysis. The industry could then argue that the proposed backfits were too expensive. The NRC asked the staff to reexamine its findings.

The NRC has long struggled with whether existing and new reactors should be required to meet the same safety standards. At a commission meeting in June, Chairman Jaczko said that the NRC might need to reassess differences in safety standards at new vs. existing reactors,

especially in considering applications for twenty year license extensions. But the agency's Executive Director for Operations, Bill Borchardt, replied that changing the current requirements for license renewals "would clearly be a major policy decision" and added that the NRC had acted too quickly in imposing new requirements after Three Mile Island. Borchardt urged the Commission to move more deliberately after Fukushima (Behr and Climatewire 2011).

On October 18 the NRC approved the staff's near-term recommendations in a Staff Requirements Memorandum (SRM). The SRM ordered the staff to implement the near-term "lessons learned" within 5 years and provided guidance on conducting rulemakings within 24-36 months to enhance station blackout capabilities. A majority of the commission demanded that the proposal for how plants cope with a prolonged blackout be in the form of an advanced notice of proposed rulemaking rather than a proposed rule; this decision could potentially delay implementation of those measures for up to two years. In the SRM, the Commission also directed the staff to again justify and re-state its views that existing rectors must undergo retrofits to incorporate these upgrades in order to provide for the "adequate protection" of the public (Markey 2011b).

After months of back and forth with the staff, in December the Commission approved the staff's recommendations for the prioritization and implementation of the Near-Term Task Force's recommendations, with some changes. Tier 1 recommendations had the highest priority and were presumed to have the greatest safety benefit; implementation of these measures would be initiated by orders to plant owners in March 2012, and were to be completed by licensees by December 31, 2016. Tier 2 recommendations would be implemented by rulemaking beginning in March 2016 and completed several years later, pending available resources (those that require

additional information or availability of critical skill sets). The Commission did not determine an implementation schedule for Tier 3 recommendations but noted that they would likely occur after the Tier 2 items. Tier 3 items would be evaluated at a later date based on the availability of additional information from Japan and the results obtained form implementing Tier 1 items. NRC staff was directed to provide a paper to the Commission by September 2012 outlining a schedule and plan for implementing them (Lochbaum and Lyman 2012).

It is also worth noting that the Commission voted to reject a recommendation by both the staff and the Near-Term Task Force to consider all of the post-Fukushima safety upgrades to be mandatory for the "adequate protection" of the public. A majority of the Commission said it was "premature" to approve this recommendation. As a result, safety upgrades could be required to undergo a cost-benefit analysis under the backfit rule (Markey 2012b).

Implementing the NTTF Recommendations

On March 12, 2012, one year and a day after the Fukushima meltdowns, the NRC issued its first regulatory requirements based on the NTTF recommendations. The NRC issued three orders requiring safety enhancements of operating reactors, construction permit holders, and combined license holders. These orders require nuclear power plants to implement safety enhancements related to (1) mitigation strategies to respond to extreme natural events resulting in the loss of power at plants, (2) ensuring reliable hardened containment vents, and (3) enhancing spent fuel pool instrumentation. The NRC also issued a request for information, directing each licensee to reevaluate the seismic and flooding hazards at their sites using current methods and data, to conduct walkdowns of their facilities to ensure protection against the hazards in their current design basis, and to reevaluate their emergency communications systems

and staffing levels. In addition, the Commission approved a staff plan for implementing the orders. The plants are required to promptly begin implementation of the safety enhancements and to complete implementation within two refueling outages or by December 31, 2016, whichever comes first.

In the end, a majority of the Commission decided that the first two orders were necessary for the "adequate protection" of the public and were thus not subject to an additional cost-benefit analysis before implementation. That was not the case with respect to the order requiring enhanced spent fuel instrumentation at existing reactors. An examination of the commission's votes shows that Jaczko voted in support of all of the staff recommendations, while Ostendorrf and Magwood supported one, and Svinicki none. Congressman Markey said that "the inability of the Commission to unanimously accept its own staff's recommendations on these most straightforward safety measures presents an ominous signal of the manner in which the more complicated next sets of safety measure will be considered" (Markey 2012).

The NRC: Lapdog or Watchdog?

In 1977 Congress abolished the Atomic Energy Commission amid concerns that its ability to regulate the nuclear industry was compromised because of its statutory mandate to promote and develop the industry. The newly established Nuclear Regulatory Commission inherited its regulatory responsibilities, while the research, development, and promotional duties were assigned to a new Department of Energy. But the NRC never became a vigilant regulator, as illustrated by its first official action: adopting all of the AEC's rules and procedures. Despite changes to its name and address, the new agency inherited its predecessor's personnel and

promotional attitudes and because the NRC was responsible for overseeing just one industry, it was an ideal candidate for regulatory capture (Duffy 1997). That basic fact remains true today.

What follows are brief discussions of specific examples of NRC actions or decisions that illustrate its regulatory approach. Time and again the agency has failed to address known safety issues, failed to enforce its own rules, or changed them at the industry's behest. The agency has also acted to suppress information that could prove damaging to the industry.

Fire Protection

Fires are one of the most significant risks for nuclear power plants. Fires can disable the cables that power the various pumps, valves, and other equipment needed to cool reactors. In fact, fires can represent as much as 50 percent of a plant's core damage frequency—the likelihood of an accident that affects the reactor's fuel. Despite the danger, the NRC has failed to address the problem, and the agency's own records show an average of ten fires per year since 1995 (Sullivan 2011b).

The NRC is acutely aware of the problem. Following a significant fire at the TVA's Browns Ferry plant in 1975, the NRC issued fire protection rules in 1980, and again in 2004. The Browns Ferry fire destroyed supposedly redundant sets of power cables because the cables were located too close together. Accordingly, the first set of rules sought to address that problem by requiring utilities to separate primary and backup cables by at least 20 feet; where this was impossible, they instead had to install fire protection measures, such as sprinklers, fireproof wrappings, or fire barriers, that could protect cables for up to three hours. The dilemma for existing plants was that the rules required extensive backfits. The industry opposed the rules and sued to stop them, but a federal judge agreed that they were necessary. NRC inspections later

revealed that some plants had installed defective fireproofing materials, while others had failed to do anything to implement the new rules. Still others were using a multitude of unapproved "work arounds" in an effort to comply. Finally, in 2001 the NRC advised inspectors that the unapproved measures were in fact violations of the rules and would no longer be tolerated. Plant owners would thus have to address unprotected cables and missing fire barriers, detectors and sprinklers. Faced with the threat of numerous violations and enormous retrofitting costs, the Nuclear Energy Institute asked for a delay in enforcement in a 2002 meeting (Sullivan 2011a).

In 2004 NRC developed an alternative approach to fire protection. Under the proposal, plant owners could choose to comply with the 1980 rules, or with a new proposal that allowed owners to tailor fire protection measures to individual plants based on a detailed risk analysis conducted by their own engineers. While the utilities developed their plans, the NRC agreed to use "enforcement discretion," in which inspectors would issue violations for only the most serious safety issues. In a further nod to the industry, the NRC asked NEI to help write the official guidance for engineers to follow while developing the new plans. Owners of fifty reactors signed up for the 2004 rules but only two test plants completed their overhauls (Sullivan 2011a). Shockingly, almost half of U.S. reactors still do comply with either set of rules, and their owners have made no firm commitments to address the issue. Instead, many plants continue to rely on fire watches while they work on new plans, and many continue to have unprotected equipment, inadequate fire doors, and missing alarms and sprinklers. Interestingly, the agency does not maintain a list of fire safety problems at plants—companies have a list so that inspectors can review them, but the lists are not publicly available (Sullivan 2011a). According to David Lochbaum of the Union of Concerned Scientists, "The NRC has basically granted all these

people the ability to not meet the regulations with impunity. They can continue to drag their feet, and the NRC just sits there and watches" (Sullivan 2011a).

Ironically, the failure of the NRC's approach to fire protection is best illustrated by the Browns Ferry plant, which had been closed by the 1975 fire. The Tennessee Valley Authority, which owns the plant, spent $1.8 billion on upgrades, including 200 miles of cables, but NRC inspectors warned them that they still did not comply with new rules. The inspectors noted an extensive number of work arounds, but the NRC eventually relented in 2007 and allowed the plant to restart, with TVA promising to fix the problems "later". When NRC inspectors returned to the plant in 2009 they found that the plant's cables were still not adequately protected. The NRC issued a formal notice of violation in 2010, and TVA admitted that it had taken no action between 2006-09 to comply with the fire protection rules. Despite assurances from TVA, the problems have not been fixed (Sullivan 2011a).

In May 2011, just 2 months after Fukushima, the NRC voted 4-1 to continue its policy of citing only the most serious fire violations (Sullivan 2011b). The following month the Commission voted to extend the deadline for compliance until 2016 (Union of Concerned Scientists 2011). Chairman Jaczko criticized the agency for not enforcing its fire protection rules, calling it "unacceptable". That some month a fire knocked out cooling to the spent fuel pool at the Fort Calhoun reactor (Lochbaum 2012). Although the NRC has denied more than forty applications for exemption from fire rules, a 2008 GAO report found that the agency had approved more than 900 exemptions to the rules. (Sullivan 2011a). That ratio suggests that the agency has acted to protect the industry rather than the public.

Inspection Resources

Critics of the NRC have suggested that the agency's inspection process is flawed, that the agency does not devote enough resources to inspections, and that NRC management frequently overrides staff recommendations on safety ratings for individual plants (Lochbaum 2011). Questions about the efficacy of NRC inspections arose after workers at the Davis-Besse reactor discovered a large hole in the reactor's vessel head in 2002. The NRC subsequently estimated that the case represented the greatest risk of a reactor meltdown than any other incident since TMI in 1979; the facility was closed for two years for repairs. According to the Union of Concerned Scientists, NRC inspectors failed to discover the problem because the agency had assumed that the plant was a "good citizen" and, because the inspection region lacked inspection resources, they were instead devoted to other plants presumed to be more problematic. More broadly, the UCS has alleged that NRC perceptions, not actual plant performance, affected how often it inspected the Davis-Besse plant, and explains why the agency minimized the importance of problems its inspectors did find (Lochbaum 2011).

Moreover, the UCS claims that this was not an unusual circumstance, citing claims by NRC employees who said that management based decisions about the level of safety problems on available resources rather than on safety significance. Indeed, a UCS review of the NRC's Reactor Oversight Program suggests that limits on NRC inspection resources may play a role in deciding when plants are moved to and from the agency's watch list. For example, the number of reactors under greatest scrutiny is fairly constant year to year, and across inspection regions. One interpretation of this data is that a relatively equal distribution of NRC resources between regions can lead to a relatively equal distribution of plants on the agency's watch list (Lochbaum 2011).

In an April 2012 letter to the NRC's five commissioners and Congressman Ed Markey (D-MA), ranking member of the House Energy committee, staff from the NRC's Western regional office complained that their manager had "openly berated and intimidated inspectors for raising safety issues" and had downplayed their concerns in discussions with his superiors. The letter claimed that the manager had tried to override inspectors' conclusions about a fire at the Fort Calhoun reactor in Nebraska. The plant had a fire In June 2011 that qualified as a "red" event, signifying a high-level threat to the plant's operations (Tracy and Johnson 2012). According to the staff letter, the manager had said the "red" classification would create a "political environment" making his job more difficult. Moreover, the letter alleged that when the manager traveled to NRC headquarters to discuss the matter, he told his superiors that the equipment deficiencies identified were "not significant" and that the staff agreed with his assessment. The letter also said that in at least two cases, employees received downgrades in their performance evaluations after identifying violations, and noted the existence of a "corrosive environment which inhibits the ability of inspectors to identify safety-significant issues" (Tracy and Johnson 2012).

Emergency Diesel Generators

The failure of emergency diesel generators was one of the factors contributing to the Fukushima meltdowns; tsunami waves inundated the generators, rendering them inoperable. NRC rules stipulate that emergency diesel generators are required to have enough fuel for 7 days in the event of a loss of power to the reactor site, as well as sufficient battery capacity for 4-8 hours in case the generators are unavailable. In 2007 the NRC issued an Information Notice describing recurring failures in generators, but required no specific action.[2] But a review of NRC

records indicates that the problem has not been resolved: since 2003, there were 69 reports of emergency diesel generators being inoperable at 48 reactors, including six instances that lasted more than one month. In those cases, the reactors sole power backup in the event of a loss of power to the site were the batteries, which provide only 4-8 hours of power (U.S. Congress 2011a).

Seismic Protections

The NRC frequently "grandfathers" existing reactors from new regulatory requirements, essentially applying different safety standards to reactors built at different times. In 1985, for example, the NRC required new reactors to incorporate design features that would make their sump screens less likely to become clogged with debris during an accident, but exempted existing reactors from the new rules. Furthermore, these exemptions apply even when existing reactors are considered for license extensions.

In another example, in 1996, after considering new data that showed that earthquakes were both more common and of greater magnitude than previously believed, the NRC revised its rule governing seismic hazards in the central and eastern US. The new rules required new reactors to design protection levels for the revised seismic hazards, but the agency did not require the 27 reactors already operating in those regions to do anything. As a result, critics allege that the seismic protection levels for these reactors remain too low (Lochbaum 2012). Although the technical staff has recommended action, based on newer data which suggested that the risk of core damage is greater than previously believed, the NRC has done nothing. Despite these concerns, the Commission approved license extensions for the Indian Point and Pilgrim reactors, both located in densely populated areas near New York City and Boston (U.S. Congress 2011a).

The NRC's dilemma is that requiring additional safety standards for new reactors, but not existing ones, implicitly undercuts its repeated assertions that creates older reactors are safe.

Licensing Issues

NRC staff documents also demonstrate a reluctance to allow Fukushima-related safety reviews to delay licensing actions. This is again consistent with the NRC's historical behavior; the agency has established goals for competing business dealings, such as licensing reviews, in a timely manner, but it has not established similar goals for resolving outstanding safety issues, some of which have lingered for more than three decades (Union of Concerned Scientists 2011). This tendency was on display just ten days after Fukushima, when the Commission voted to extend the license for the problem plagued Vermont Yankee reactor, and again one month later, when it extended the licenses of Palo Verde units 1,2 and 3. As noted above, in February 2012 the Commission approved a combined license for two reactors at Southern Company's Vogtle, Georgia location. The license was approved without requiring a license condition that the post-Fukushima safety recommendations made by the Near-Term Task Force be mandatory for the reactors (Markey 2012b). In approving the application, four of the commissioners disregarded staff concerns that the containment of the new Westinghouse AP 1000 designs was brittle and could break in an earthquake or if struck by a commercial aircraft. Just one month after that, the Commission voted to approve combined licenses for two reactors at the Virgil C. Summer plant in South Carolina. This time, the Commission imposed two conditions on the license: the first requires inspection and testing of squib valves, a component of the new passive cooling system; the second requires development of strategies for how to respond to extreme natural events

resulting in the loss of power. The NRC also issued an order requiring the use of enhanced, reliable spent fuel instrumentation (U.S. NRC 2012c).

These actions, taken before the Commission has completed its Fukushima safety reviews and, in the case of the Vogtle decision, even before the NRC had approved any new safety measures, is quite remarkable. At a minimum, it suggests that the agency is eager to demonstrate that the Fukushima accident will not delay or hinder plans to develop the next generation of nuclear plants. It is expected that the agency will ultimately approve license extensions for approximately 90 of the nation's 104 operating reactors (U.S. Congress 2011a).

Power Uprates

The NRC's handling of uprating existing reactors also illustrates its efforts to aid the industry. Uprating involves technical changes to reactors, such as the use of more highly enriched uranium, which increases the power output of a reactor. The NRC routinely approves such requests, granting 135 uprates from 1977-2011. In many cases, uprates are considered to be minor, boosting output by 5 to 10 percent, so-called "extended uprates" can increase a reactor's output by 15 to 20 percent (Schneider, Froggatt, and Thomas 2011; U.S. NRC 2012). Perhaps the most noteworthy example involves the Commission's decision, just five days after Fukushima, to approve a staff proposal to ignore a recommendation by the Advisory Committee on Reactor Safeguards (ACRS) to ensure that safety measures that are assumed to address the hotter reactor cores and higher pressures associated with power uprates would work to prevent a meltdown in the event of an accident. The ACRS believed that the NRC should consider the possibility that a fire or earthquake could breach the containment, but the Commission sided with the staff in a 4-1 vote (Markey 2012b).

Conclusions

Like the accidents at Three Mile Island and Chernobyl, and the terrorist attacks of September 11, the meltdowns at Fukushima have forced the NRC to review its rules and procedures and the adequacy of safety measures at existing reactors. In fact, the NRC has already adopted new requirements for seismic activity, spent fuel pools and containment structures, and emergency planning; additional measures are also likely. If past is prologue, these new requirements will lead to added costs for the industry, and nuclear power will thus become more expensive. As Cooper (2011b) has noted, accidents at nuclear plants typically lead to a re-examination of risks which then lead to more stringent safety regulations and higher construction costs. For an industry that just a few years earlier had been proclaiming its imminent revival, this rapid reversal of fortunes is most unwelcome. It is therefore not surprising that the industry has worked to limit and delay additional safety measures that could further increase their costs and undermine its economic viability.

Nor is it surprising, given its history, that the NRC has been receptive to these efforts, as illustrated by the agency's handling of the NTTF recommendations. In a statement marking the one-year anniversary of the Fukushima accidents, Congressman Ed Markey lamented that "The majority of NRC Commissioners have consistently voted to reject the recommendations of the NRC Near-Term Task Force and implement the upgrades in a manner that acknowledges that they are necessary to ensure the adequate protection of nuclear power plants. We need the NRC to be an industry watchdog, not an industry lapdog" (Markey 2012). Markey's statement followed two staff reports documenting numerous instances in which commissioners and some senior staff tried to delay the creation of the NTTF, shape its work, and then weaken, defeat or

delay many of its specific policy recommendations. On several recommendations a majority of the NRC commissioners even voted contrary to the agency's staff (U.S. Congress 2011a; U.S. Congress 2011b).

These findings echo those of the Union of Concerned Scientists, whose own 2012 review of safety issues at U.S. nuclear plants concluded that plant owners and the agency tolerated known problems and failed to address them properly, noting that "the agency too often does not live up to its potential, and we are still finding significant problems at nuclear plants that could too easily trigger a serious accident" (Lochbaum 2012).

The Nuclear Regulatory Commission has never been an aggressive watchdog for nuclear safety, and its tentative response thus far to Fukushima is yet another example of how reluctant the agency has been to impose more stringent rules on the nuclear industry. In the words of Jim Riccio, a nuclear analyst with Greenpeace, "The NRC has a problem distinguishing between the public they serve and the industry they regulate" (Sullivan 2011c). If the worst nuclear disaster in history is not enough to rouse the NRC, it is reasonable to ask what, if anything, could.

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Appendix 1: Near-Term Task Force Recommendations

Clarifying the Regulatory Framework

1. The Task Force recommends establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations. (Section 3)

Ensuring Protection

2. The Task Force recommends that the NRC require licensees to reevaluate and upgrade as necessary the design-basis seismic and flooding protection of structures, systems, and components for each operating reactor. (Section 4.1.1)
3. The Task Force recommends, as part of the longer term review, that the NRC evaluate potential enhancements to the capability to prevent or mitigate seismically induced fires and floods. (Section 4.1.2)

Enhancing Mitigation

4. The Task Force recommends that the NRC strengthen station blackout mitigation capability at all operating and new reactors for design-basis and beyond-design-basis external events. (Section 4.2.1)
5. The Task Force recommends requiring reliable hardened vent designs in boiling water reactor facilities with Mark I and Mark II containments. (Section 4.2.2)
6. The Task Force recommends, as part of the longer term review, that the NRC identify insights about hydrogen control and mitigation inside containment or in other buildings as additional information is revealed through further study of the Fukushima Dai-ichi accident. (Section 4.2.3)
7. The Task Force recommends enhancing spent fuel pool makeup capability and instrumentation for the spent fuel pool. (Section 4.2.4)
8. The Task Force recommends strengthening and integrating onsite emergency response capabilities such as emergency operating procedures, severe accident management guidelines, and extensive damage mitigation guidelines . (Section 4.2.5)

Strengthening Emergency Preparedness

9. The Task Force recommends that the NRC require that facility emergency plans address prolonged station blackout and multiunit events. (Section 4.3.1)
10. The Task Force recommends, as part of the longer term review, that the NRC pursue additional emergency preparedness topics related to multiunit events and prolonged station blackout. (Section 4.3.1)
11. The Task Force recommends, as part of the longer term review, that the NRC should pursue emergency preparedness topics related to decisionmaking, radiation monitoring, and public education. (Section 4.3.2)

Improving the Efficiency of NRC Programs

12. The Task Force recommends that the NRC strengthen regulatory oversight of licensee safety performance (i.e., the Reactor Oversight Process) by focusing more attention on defense-in-depth requirements consistent with the recommended defense-in-depth framework. (Section 5.1)

Source: U.S. NRC 2011, ix.

[1] By statute, the NRC consists of five commissioners, appointed by the President and subject to Senate confirmation. No more than three members of the commission may be from the same political party. The other four commissioners were all appointed or re-appointed by President Obama. Prior to his nomination in 2009, William Magwood served for seven years as the head of the Office of Nuclear Energy at the Department of Energy. George Apostolakis, appointed in 2010, had been a professor of Nuclear Science and Engineering and a professor of Engineering Systems at the Massachusetts Institute of Technology. He was also a member and former Chairman of the statutory Advisory Committee on Reactor Safeguards of the NRC. The two Republican members of the NRC are Kristine Svinicki and William Ostendorff. Before being nominated to the Commission in 2008 by George W. Bush, Svinicki had worked as a Senate staffer on national security, science and technology, and energy issues. President Obama reappointed her in 2012 after Republican senators threatened to shut down the Senate if she were not. Ostendorff, who previously served as Director of the Committee on Science, Engineering and Public Policy and as Director of the Board on Global Science and Technology at the National Academies, was nominated by Obama to fill a vacancy in 2010, and was reappointed to a full term in 2011 (U.S. NRC 2012e).

[2] The NRC issues information notices to provide licensees with significant recently identified information about safety, safeguards, or environmental issues. Licensees are typically expected to review the information to see if they are relevant to their plants and to consider actions, as appropriate, to avoid similar problems.