Testimony of Dr. Edwin Lyman

Senior Scientist, Global Security Program

Union of Concerned Scientists

"An Examination of the Safety and Economics of Light Water Small Modular Reactors"

Before the

Energy and Water Development Subcommittee

Committee on Appropriations

U.S. Senate

July 14, 2011

Good morning. On behalf of the Union of Concerned Scientists, I would like to thank Chairman Feinstein, Ranking Member Alexander, and the other distinguished members of the Subcommittee for the opportunity to provide our views on the safety and economics of light water small modular nuclear reactors.

The Union of Concerned Scientists is neither pro nor anti-nuclear power, but has served as a nuclear power safety and security watchdog for over 40 years. UCS is also deeply concerned about global climate change and has not ruled out an expansion of nuclear power as an option to help reduce greenhouse gas emissions—provided that it is affordable relative to other low-carbon options and that it meets very high standards of safety and security. However, the Fukushima Daiichi crisis has revealed significant vulnerabilities in nuclear safety and has shaken public confidence in nuclear power. If we want to reduce the risk of another Fukushima in the future, new nuclear plants will have to be substantially safer than the current generation. To this end, we believe that the nuclear industry and the Energy Department should work together to focus on developing safer nuclear plant designs, and that Congress should direct the Energy Department to spend taxpayer money only on support of technologies that have the potential to provide significantly greater levels of safety and security than currently operating reactors. The nuclear industry will have to work hard to regain the public trust.

Proponents of small modular reactors (SMRs) claim that their designs have inherent safety features compared to large reactors, and some even argue that their reactors would have been able to withstand an event as severe as Fukushima. We find these claims to be unpersuasive. For any plant, large or small, the key factor is the most severe event that the plant is designed to withstand—the so-called maximum "design-basis" event. Unless nuclear safety requirements for new reactors are significantly strengthened, one cannot expect that either small or large reactors will be able to survive a beyond-design-basis event like Fukushima. Although some light-water SMR concepts may have desirable safety characteristics, unless they are carefully designed, licensed, deployed and inspected, SMRs could pose comparable or even greater safety, security and proliferation risks than large reactors.

Some SMR vendors argue that their reactors will be safer because they can be built underground. While underground siting could enhance protection against certain events, such as aircraft attacks and earthquakes, it could also have disadvantages as well. For instance, emergency diesel generators and electrical switchgear at Fukushima Daiichi were installed below grade to reduce their vulnerability to seismic events, but this increased their susceptibility to flooding. And in the event of a serious accident, emergency crews could have greater difficulty accessing underground reactors.

Some SMR vendors emphasize that their designs are "passively safe." However, no credible reactor design is completely passive and can shut itself down and cool itself in every circumstance without need for intervention. Some reactor designs, large or small, have certain passive safety features that allow the reactor to depend less on operator action for a limited period of time following design-basis accidents. Small reactors may have an advantage because the lower the power of a reactor, the easier it is to cool through passive means such as natural convection cooling with water or even with air. However, accidents affecting multiple small units may cause complications that could outweigh the advantages of having lower heat removal requirements per unit. Moreover, passively safe reactors generally require some equipment, such as valves, that are designed to operate automatically but are not one hundred percent reliable.

Operators will always be needed to monitor systems to ensure they are functioning as designed, and to intervene if they fail to do so. Both passive systems and operator actions would require functioning instrumentation and control systems, which were unreliable during the severe accidents at Three Mile Island and Fukushima. Passive systems may not work as intended in the event of beyond-design-basis accidents, and as result passive designs should also be equipped with highly reliable active backup systems and associated instrumentation and control systems.

But more backup systems generally mean higher costs. This poses a particular problem for SMRs, which begin with a large economic disadvantage compared to large reactors.

According to the standard formula for economies of scale, the overnight capital cost per kilowatt of a 125 megawatt reactor would be roughly 2.5 times greater than that of a 1250 megawatt unit, all other factors being equal. Advocates argue that SMRs offer advantages that can offset this economic penalty, such as a better match of supply and demand, reduced up-front financing costs, reduced construction times, and an accelerated benefit from learning from the construction of multiple units. However, a 2007 paper by Westinghouse scientists and their collaborators that quantified the cost savings associated with some of these factors found that they could not overcome the size penalty: the paper found that at best, the capital cost of four 335 megawatt reactors was slightly greater than that of one 1340 megawatt reactor.[1]

Given that there is no apparent capital cost benefit for SMRs, it is not surprising that the SMR industry is seeking to reduce operating and maintenance (O&M) costs by pressuring the Nuclear Regulatory Commission to weaken certain regulatory requirements for SMRs. Deputy Assistant Energy Secretary John Kelly told the Nuclear Regulatory Commission in March that the NRC's regulatory requirements for SMRs will "directly influence the operating cost, which will be a large determinant into the economic feasibility of these plants."

For example, the industry argues that regulatory requirements for SMRs in areas such as emergency planning, control room staffing and security staffing can be weakened because SMRs contain smaller quantities of radioactive substances than large reactors and therefore pose lower risks to the public. The NRC is currently considering the technical merits of these arguments.

However, small reactors will not necessarily be safer than large reactors on a per-megawatt basis. Simply put, the risk to the public posed by one 1200-megawatt reactor will be comparable to that posed by six 200-megawatt reactors (assuming that all units are independent), unless the likelihood of a serious accident is significantly lower for each small reactor. But such an outcome will not be assured under the current regulatory regime. The Nuclear Regulatory Commission has a long-standing policy that new nuclear reactors, large or small, are not required to be safer than operating reactors. One consequence of this policy is that new reactor designs that have inherent safety features not present in current reactors may not actually end up being safer in the final analysis if designers compensate by narrowing safety margins in other areas, such as by reducing containment strength or the diversity and redundancy of safety systems.

[1] M.D. Carelli et al., "Economic Comparison of Different Size Nuclear Reactors," 2007 LAS/ANS Symposium, Cancun, Mexico, 1-5 July 2007. Available at http://www.las-ans.org.br/Papers%202007/pdfs/Paper062.pdf

Any safety advantages will be eroded further if the NRC allows SMR owners to reduce emergency planning zones and the numbers of required operators and security officers.

One of the early lessons from Fukushima is that prevention of serious nuclear accidents requires significant margins of safety to protect against extreme events. Earlier this week, UCS and the NRC's Fukushima Near-Term Task Force each issued recommendations for strengthening nuclear safety requirements. Consider the following examples:

- Emergency planning zones around U.S. nuclear plants extend to a radius of ten miles. Yet significant radiological contamination from the Fukushima accident has been detected well beyond a distance of ten miles from the plant. In fact, radiation levels high enough to trigger resettlement if they occurred in the United States have been detected over 30 miles away from the Fukushima site. The discussion we should be having today is whether current emergency planning zones need to be increased, not whether we can shrink them for SMRs.
- As we have seen at Fukushima, nuclear plants with multiple reactors that experience severe accidents present extreme challenges. In its June 2011 report to the International Atomic Energy Agency, the Nuclear and Industrial Safety Agency of Japan (NISA) stated that:

  "The accident occurred at more than one reactor at the same time, and the resources needed for accident response had to be dispersed. Moreover, as two reactors shared the facilities, the physical distance between the reactors was small ... The development of an accident occurring at one reactor affected the emergency responses at nearby reactors.

  "Reflecting on the above issues, Japan will take measures to ensure that emergency operations at a reactor where an accident occurs can be conducted independently from operation at other reactors if one power station has more than one reactor. Also, Japan will assure the engineering independence of each reactor to prevent an accident at one reactor from affecting nearby reactors. In addition, Japan will promote the development of a structure that enables each unit to carry out accident responses independently, by choosing a responsible person for ensuring the nuclear safety of each unit."

  The NRC will need to consider these issues in developing its licensing approach for small modular reactor sites, which may host two to four times the number of units present at the largest U.S. nuclear plant site today. The NRC has acknowledged that some of its current regulations and procedures do not account for events affecting multiple units on a site. For instance, according to the NRC, emergency planning regulations focus on single-unit events with regard to requirements for emergency operations staffing, facilities and dose projection capability. Also, the NRC's guidance for probabilistic risk assessment, an analysis tool which is used in many regulatory applications, does not require the consideration of multiple-unit events. The NRC Fukushima Near-Term Task Force is recommending that emergency preparedness requirements be revised to address multi-unit events, which could have a significant impact on SMR licensing.
- Fukushima also demonstrated how rapidly a nuclear reactor accident can progress to a core meltdown if multiple safety systems are disabled. A well-planned and executed terrorist attack could cause damage comparable to or worse than the earthquake and

> tsunami that initiated the Fukushima crisis, potentially in even less time. And although Osama bin Laden is gone, the terrorist threat to domestic infrastructure may actually increase over time if al Qaeda seeks to retaliate. This is the wrong time to consider reducing security requirements for nuclear power plants, regardless of their size. However, SMR vendors have emphasized that reducing security staffing is critical for the economic viability of their projects. Christofer Mowry of B&W told the NRC in March that "whether SMRs get deployed in large numbers or not is going to come down to O&M [operations and maintenance]. And the biggest variable that we can attack directly … is the security issue." A Nuclear Energy Institute representative said in a presentation in June that "optimal security staffing levels [for SMRs] may appreciably differ from current levels."

UCS is also concerned that reducing safety and security requirements for SMRs could facilitate their sale to utilities or other entities in the United States and abroad that do not have prior experience with nuclear power. Some SMR vendors argue that their technology is so safe that it can be deployed to remote areas, military bases, and countries in the developing world that have relatively low electric demand and no nuclear experience or emergency planning infrastructure. However, SMRs deployed in this manner could raise additional safety and security concerns compared to their deployment by established and experienced nuclear utilities.

The distributed deployment of small reactors would also put great strains on existing licensing and inspection resources. Nuclear reactors are qualitatively different from other types of generating facilities, not least because they require a much more extensive safety and security inspection regime. Similarly, deployment of individual small reactors at widely distributed and remote sites around the world would strain the resources of the International Atomic Energy Agency (IAEA) and its ability to adequately safeguard reactors to guard against proliferation, since IAEA inspectors would need to visit many more locations per installed megawatt around the world. Maintaining robust oversight over vast networks of SMRs around the world would be difficult, if feasible at all.

UCS believes that SMRs are only suitable for deployment where there is an established infrastructure to cope with emergencies, and if sufficient numbers of trained operator and security staff can be provided. It is unrealistic to assume the near-term availability of SMRs that are so safe they can be shipped around the world without the need to ensure the highest levels of competence and integrity of local regulatory authorities, plant operators, emergency planning organizations and security forces. Fukushima has demonstrated the importance of timely off-site response in the event of a severe accident, so the accessibility of reactors in remote locations also must be a prime consideration. Even within the U.S., small utilities with little or no experience in operating nuclear plants need to fully appreciate the unique challenges and responsibilities associated with nuclear power and should not expect that small modular reactors will provide any relief in this regard.

UCS acknowledges the concerns of members of Congress who fear that the United States is lagging in creation of a robust SMR export market and may lose out to a country like China if it takes too long to develop and license SMRs. However, we believe that the best way for the United States to maintain a competitive edge is to establish American brands with the highest

safety standards. If, as some say, NRC design certification is seen as a "gold standard" worldwide, it makes sense to preserve that standard rather than erode it by weakening SMR safety requirements.

To this end, Congress should prohibit DOE from selecting SMR proposals for its cost-sharing program if their business case depends on a weakening of NRC safety and security regulations or marketing reactors to countries with inadequate safety rules and regulatory oversight mechanisms.

Thank you for your attention. I would be pleased to answer your questions.