UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 52-047-ESP
Tennessee Valley Authority	)	
	)	
(Clinch River Nuclear Site)	)	

INTERVENORS' MOTION FOR LEAVE TO FILE CONTENTION 4 (INADEQUATE DISCUSSION OF ENVIRONMENTAL IMPACTS OF SPENT FUEL POOL FIRES) AND CONTENTION 5 (IMPERMISSIBLE DISCUSSION OF ENERGY ALTERNATIVES AND NEED FOR THE PROPOSED SMR)

Diane Curran
Harmon, Curran, Spielberg, & Eisenberg, L.L.P.
1725 DeSales Street N.W., Suite 500
Washington, D.C. 20036
240-393-9285
dcurran@harmoncurran.com

May 21, 2018

TABLE OF CONTENTS

INTERVENORS' MOTION FOR LEAVE TO FILE CONTENTION 4 (INADEQUATE DISCUSSION OF ENVIRONMENTAL IMPACTS OF SPENT FUEL POOL FIRES) AND CONTENTION 5 (IMPERMISSIBLE DISCUSSION OF ENERGY ALTERNATIVES AND NEED FOR THE PROPOSED SMR)

I. INTRODUCTION

Pursuant to 10 C.F.R. §§ 2.309(c) and 2.309(f), Intervenors Southern Alliance for Clean Energy ("SACE") and Tennessee Environmental Council ("TEC") hereby request the Atomic Safety and Licensing Board's ("ASLB's") leave to file new Contentions 4 and 5. Both contentions address deficiencies in the Draft Environmental Impact Statement ("Draft EIS") recently issued by the U.S. Nuclear Regulatory Commission ("NRC") Staff for Tennessee Valley Authority's ("TVA's") application for an Early Site Permit ("ESP"). NUREG-2226, Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site (Draft Report for Comment, April 2018). If granted, the ESP would allow TVA to bank the Clinch River Nuclear Site as a potential site for construction and operation of a small modular reactor ("SMR").

Contention 4 challenges the adequacy of the Draft EIS' discussion of the environmental impacts of spent fuel pool accidents risks and Contention 5 challenges the Draft EIS' impermissible inclusion of information about the technical and economic benefits of building and operating the proposed SMR. As discussed in Sections III and IV below, Contentions 4 and 5 meet the NRC's standards for admissibility of contentions, as well as the NRC's "good cause" standard for filing of contentions after the original deadline for hearing requests.

II. FACTUAL AND PROCEDURAL BACKGROUND

On June 12, 2017, Intervenors submitted a hearing request and petition to intervene on TVA's ESP application for siting of an SMR at the Clinch River Site. Petition to Intervene and

Request for Hearing ("Hearing Request"). Intervenors' Hearing Request included Contention 2, which challenged TVA's failure to address the consequences of spent fuel pool fires in its Environmental Report; and Contention 3, which challenged the ER for discussing the relative technical advantages of SMRs in comparison to other energy alternatives on the ground that TVA had explicitly elected to omit those issues from the Environmental Report.

In LBP-17-08, the ASLB found Intervenors had standing and admitted Contentions 2 and 3. *Tennessee Valley Authority* (Clinch River Nuclear Site Early Site Permit Application), LBP-17-08, __ NRC __ (Oct. 25, 2017) ("LBP-17-08"). The ASLB concluded that Contention 2 was an admissible "contention of omission." *Id.,* slip op. at 27. With respect to Contention 3, the ASLB found that Intervenors had raised an admissible issue of whether information included in TVA's Environmental Report, while lawful under NRC regulations applicable to environmental reports, would be impermissible under 10 C.F.R. § 51.75(b) if it were later included in the Draft EIS. *Id.,* slip op. at 31.

In response to an appeal of LBP-17-08 by TVA, the Commission affirmed the admission of Contention 2 and reversed the admission of Contention 3 in CLI-18-05. *Tennessee Valley Authority* (Clinch River Nuclear Site Early Site Permit Application), CLI-18-05, __NRC __ (May 3, 2018). In reversing the ASLB's decision, the Commission held that "[t]he determining factor is TVA's statements, in the Environmental Report, that it has chosen to defer a discussion of need for power and energy alternatives until the combined license application, which it is permitted to do under 10 C.F.R. § 51.50(b)(2)." *Id.,* slip op. at 15.

On April 20, 2018, the NRC posted the Draft EIS on its Agencywide Documents Access and Management System. The NRC Staff notified the Board and parties of the posting by letter dated April 23, 2018. Letter from Anne Hove to Paul Ryerson, *et al.,* re: In the Matter of

TENNESSEE VALLEY AUTHORITY (Clinch River Nuclear Site Early Site Permit Application) Docket No. 52-047-ESP. Notice of the availability of the Draft EIS was published on April 26, 2018 at 83 Fed. Reg. 18,354.

III. CONTENTIONS

Contention 4: Inadequate Discussion of the Environmental Impacts of Pool Fires

1. Statement of the Contention: The Draft EIS is inadequate to satisfy the National Environmental Policy Act ("NEPA") because its conclusion that environmental impacts of a spent fuel pool accident are small is based on non-conservative or otherwise invalid assumptions that are based on the design characteristics of a light water reactor ("LWR") and compliance by TVA with all current emergency planning requirements.

First, the NRC Staff makes assumptions about patterns of fuel usage and storage at LWRs that differ significantly from the characteristics of at least one SMR design included in the proposed "plant parameter envelope" ("PPE") on which the Staff's environmental analysis is based. The Draft EIS fails to analyze those key differences. Second, the NRC Staff makes assumptions in the Draft EIS about the PPE with respect to the quantity of fuel stored in the pool that are neither conservative nor bounding for at least one of the SMR designs that comprise the PPE. Finally, the Draft EIS's environmental analysis is based on the non-conservative assumption that the ten-mile emergency planning zone ("EPZ") around the proposed SMR will be evacuated, when in fact the NRC currently is considering a request by TVA to relax that requirement. Accordingly, the Draft EIS fails to support its assertion that the risk profile for spent fuel pool fires at an LWR is bounding for the proposed SMR.

2. Brief Summary of Basis for the Contention:

a. Legal and factual basis for requiring discussion of pool fire impacts.

As discussed in Intervenors' 2017 Hearing Request, the consequences of spent fuel pool fires must be considered in any environmental analysis of the impacts of reactor operation, because the NRC has not ruled out their likelihood as remote and speculative. *State of New York v. NRC,* 681 F.3d 471, 483 (D.C. Cir. 2012). *See also* NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants at 1-28 (2013) ("License Renewal GEIS") (concluding the environmental impacts of pool fires are "comparable to those from the reactor accidents at full power.").

It is well established that the radiological consequences of a pool fire are potentially catastrophic. For instance, radioactive fallout from a pool fire could displace as many as four million people out to 500 miles. NUREG-2161, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a US Mark I Boiling Water Reactor at 169 (2014) (ADAMS Accession No. ML13297070) ("Spent Fuel Pool Study"). In the 2013 License Renewal GEIS, the NRC also concluded that the environmental impacts of a pool fire are "comparable to those from the reactor accidents at full power." *Id.* at 1-28. The potential for reactor accidents to have significant adverse public health effects within at least a ten-mile radius -- including early and latent fatalities -- is discussed in NRC's emergency planning guidance documents. *See* NUREG-0396, Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants (1978) and NUREG-0654/FEMA-REP-1, Rev. 1, Criteria for Protective Action Recommendations for Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants (1980).

b. TVA's Environmental Report and Draft EIS

In its Environmental Report, TVA claimed that the design of the spent fuel storage pool(s) for the proposed SMR has "spent fuel pool cooling without the need for active heat removal." Environmental Report at 9.3-2. But the Environmental Report did not state that the cooling system renders pool fires remote and speculative. Therefore, Intervenors asserted in Contention 2 that spent fuel pool fire impacts must be considered in the Environmental Report.

The Draft EIS constitutes the first environmental document in which TVA or the NRC Staff has addressed the probability or consequences of a pool fire at the proposed TVA SMR. In the Draft EIS, the NRC asserts that it "has reviewed the past NRC studies concerning spent fuel accidents, TVA's PPE values regarding spent fuel inventory and spent fuel pool characteristics, and the Fukushima actions in regard to spent fuel level instrumentation and mitigation." *Id.* at 5-87. The "past NRC studies" relied on in the Draft consist of the following EISs and technical studies of fuel storage at LWRs:

- NUREG-1437, Rev. 0, Generic Environmental Impact Statement for License Renewal of Nuclear Plants ("License Renewal GEIS") (1996);
- NUREG-1437, Rev. 1, Generic Environmental Impact Statement for License Renewal of Nuclear Plants ("License Renewal GEIS") (2013);
- NUREG-2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel (2014);
- NUREG-1738, Technical Study of Spent Nuclear Fuel Pool Accident Risks of Decommissioning Nuclear Power Plants (2001); and
- NUREG-2161, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel for a U.S. Mark I Boiling Water Reactor (2014) ("Spent Fuel Pool Study").

Draft EIS at 5-85 – 5-86.

The "PPE values regarding spent fuel inventory and spent fuel pool characteristics" considered in the Draft EIS include the following:

- Each reactor would be re-fueled every two years;
- Fuel would not be stored in the pool for more than six years (then transferred to an independent spent fuel storage installation); and
- A dedicated spent fuel pool would hold approximately 288 fuel assemblies, a "smaller amount of spent fuel" than NRC considered in its LWR environmental and risk analyses.

Draft EIS at 5-86. According to the Draft EIS, these PPE values "encompass four light water SMRs under development in the United States at the time of the preparation of the [Environmental Report] – the BWXT mPower™ SMR (Generation mPower LLC), Holtec SMR-160 (Holtec SMR, LLC), NuScale SMR (NuScale Power, LLC), and Westinghouse SMR (Westinghouse Electric, LLC) (TVA 2016-TN5002). The Draft EIS does not attribute any of the listed PPE elements to a particular SMR design, other than to assert that the PPE values "encompass" all four designs. *Id.*

Based on these EISs, technical studies, and PPE design assumptions, the NRC Staff asserts that it "expects the risks from spent fuel pool accidents for a design bounded by the PPE would be lower than the risks of a spent fuel pool severe accident for a large LWR." *Id.* at 5-87. As the Draft EIS further explains:

> The already remote risk of spent fuel pool fires for large LWRs, as described in the 1996 version of NUREG-1437 (NRC 1996-TN288) (1996) and confirmed in the 2013 version (NRC 2013-TN2654), would be more remote for the SMRs considered in developing the PPE based on the best available information about those SMR designs because (1) the spent fuel pools are assumed to be located underground, (2) the fuel transfer would be expedited because the pool would be significantly smaller than that of a large LWR and therefore the number of spent fuel assemblies in the pool would be much lower; and (3) implementation of the NRC orders improves the safety of the spent fuel pools and provides mitigating strategies for preventing spent fuel pool fire. Therefore, because the impact from spent fuel pool fires is considered SMALL for large LWRs, it is also SMALL for the SMRs considered for the CRN Site.

Draft EIS at 5-87.

c. Significant design differences and non-conservatisms disregarded in Draft EIS

The Draft EIS disregards significant design differences between the LWR designs on which the NRC Staff bases its environmental conclusions and at least one of the designs included in the PPE: the NuScale design. Intervenors focus on the NuScale design here because it is more developed than some of the other designs and because TVA relied on it in applying for an exemption to the NRC's emergency planning requirements. *See* letter from J.W. Shea, TVA to NRC re: Response to Request for Additional Information Related to Emergency Planning Exemption Requests in Support of Early Site Permit Application for Clinch River Nuclear Site, Enclosure 1 at 1 (Aug. 24, 2017) (ML17237A175) (citing "the availability of substantially more detailed technical information on accident progression and source term for this design than for the other designs considered in the formation of the PPE."). The Staff also makes assumptions about the PPE with respect to the quantity of fuel stored in the pool that are not conservative in light of the NuScale design.

i. Significantly different fuel discharge pattern may affect heat level in the pool.

First, the Draft EIS completely neglects a significant factor in pool fire risks: the different length of the average decay time of the spent fuel inventory in the NuScale SMR pool as compared to a LWR. Decay time is an important factor in spent fuel pool fire risk analysis because "[t]he only significant heat source initially would be the decay heat." NUREG-1738 at A1A-2. As shown in Figure 1A-1 of NUREG-1738, decay heat, which decreases with time after fuel is discharged to the pool, is a key factor in determining how long it would take for a pool fire to start:

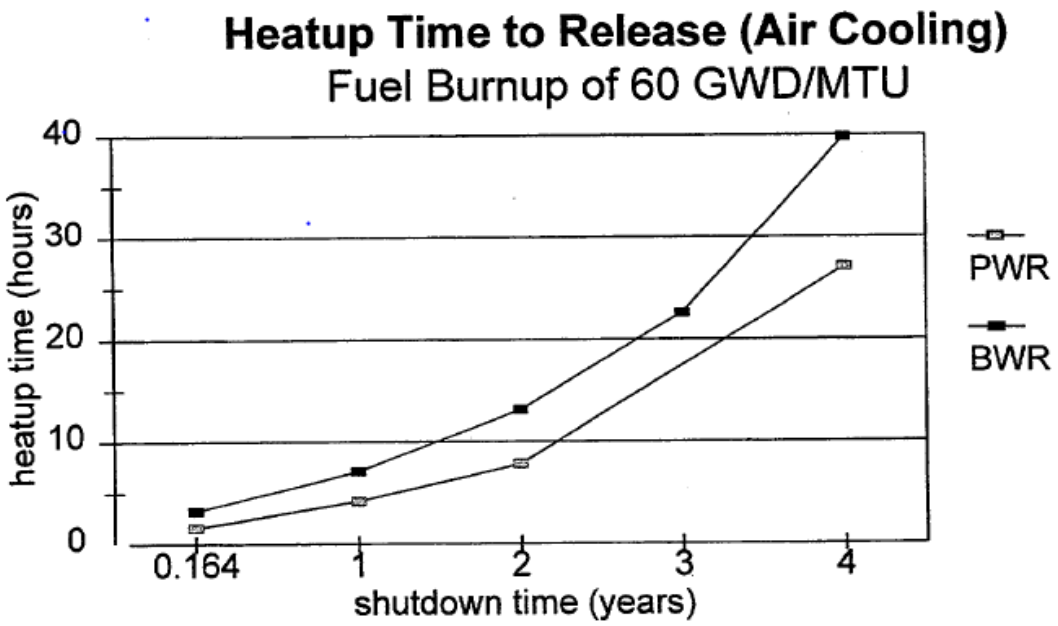


Figure 1A-1 Heatup time from 30 °C to 900 °C

Figure 1A-1 is explained by the NRC Staff as follows:

> Figure 1A-1 shows that for the configuration modeled, and for decay times of less than about 2 years for PWRs and 1.5 years for BWRs (assuming burnup of 60 GWD/MTU), it would take less than 10 hours for a zirconium fire to start or for significant fission product releases to begin once the fuel was fully uncovered and the fuel was cooled by an air flow of about two building volumes per hour. The figure also shows that after 4 years, PWR fuel could reach the point of fission product release in about 24 hours.

Id. at A1A-4. Similarly, the 2014 Spent Fuel Pool Study found that spent fuel is only susceptible to a radiological release within a few months after the fuel is moved from the reactor to the spent fuel pool." *Id.* at iii-iv. Thus, the amount of time that has passed after discharge of fuel to the pool is a significant factor in the speed at which uncovered spent fuel will ignite.

In addition to affecting the speed at which an accident occurs, decay time also affects the number of early fatalities that may occur in a spent fuel pool accident. As stated in NUREG-1738, "[a]pproximately 85 percent of all the ruthenium in the pool is in the last core off-loaded since the ruthenium-106 half-life is about 1 year." NUREG-1738, Figure 3.7-1 and Figure ES-1,

show that ruthenium-related fatalities are highest during the months directly following shutdown, *i.e.,* when the fuel in the pool is hottest.

The Staff bases its environmental analysis on the assumption that TVA will refuel each SMR at a frequency of two years. Draft EIS at 5-86. Two years is also the refueling cycle for the reference LWR studied in the Spent Fuel Pool Study. *Id.* at D-32. But the NuScale design – which the NRC Staff claims is encompassed by the Draft EIS' environmental analysis -- is distinctly different from the reference LWR with respect to its reactor design and refueling pattern. While the reference LWR in the Spent Fuel Study was assumed to discharge 296 fuel assemblies to a pool of 30,055 assemblies every two years, the NuScale design calls for twelve separate reactors that would discharge fuel to a single pool. Although each reactor will be on a two-year refueling schedule, refueling of all twelve reactors will be "staggered," *i.e.,* fuel will be discharged to the fuel every two months rather than every two years.[1] In contrast to an LWR pool, in which the hottest fuel is present only once every two years, the hottest fuel will be added to the SMR pool every two months. This pool loading pattern will result in different probabilities of zirconium fire ignition over an operating cycle than those used in NUREG-2161 and other past NRC studies to estimate public health and environmental impacts of pool fires at large LWRs. The Draft EIS completely fails to address the risk implications of this significant design difference from the large LWRs analyzed in previous NRC studies.

---

[1] As stated by NuScale in a 2012 article in Nuclear Technology:

> The 12-module NuScale plant uses an in-line refueling approach in which each module is refueled once every 2 years. Refueling is performed remotely using underwater flange stud tensioning/detensioning tools. That is, refueling operations would occur in a staggered manner at roughly 2-month intervals.

José N. Reyes, NuScale Plant Safety in Response to Extreme Events, Nuclear Technology Vol. 178 at 1 (May 2012). http://www.nuscalepower.com/images/our_technology/nuscale-safety-nucl-tech-may12-pre.pdf (last visited May 21, 2018).

ii. Assumptions related to quantity of fuel stored in pool are not conservative.

The Draft EIS' finding of small impact from spent fuel pool fires is based in part on the conclusion that "spent fuel transfer would be expedited because the pool would be significantly smaller than that of a large LWR and therefore the number of spent fuel assemblies in the pool would be much lower." *Id.* at 5-87. This conclusion is based, in turn, on two key assumptions: that the pool would hold only 288 fuel assemblies, and that the fuel would not remain in the pool more than six years. *Id.* at 5-86. But neither the NRC Staff nor TVA cites any regulatory requirements to support these assumptions. Although the pool would hold up to 288 assemblies per module, the required capacity would be proportionately larger if multiple modules were at the site. Also, the NRC places no regulatory limit on the size of a spent fuel pool. Nor do NRC regulations contain any requirement to expedite transfer of fuel from storage pools before capacity limits are reached. TVA's Environmental Report asserts that NRC requires fuel to remain in the pool for at least five years (TVA Environmental Report at 5.7-12) – but this is a minimum requirement, not a limit. And at least one other SMR design that TVA used to develop its surrogate plant, such as mPower, would have a spent fuel pool sized to store all spent fuel discharges over the lifetime of the plant.

Recently-issued documents from NuScale indicate that not only is the NuScale design generally capable of storing spent fuel for more than six years, but it appears that the design of the pool has not yet been finalized. On May 19, 2018, NuScale issued a graphic presentation on "Spent Fuel Safety," which stated that: "The NuScale spent fuel pool provides storage for up to 10 years of spent fuel storage, plus temporary storage for new fuel assemblies." *See* Attachment 1. On the same date, NuScale issued a different graphic presentation, entitled "Safety Features of the NuScale Design," which states: "The spent fuel pool provides storage space for up to 15

years of accumulated spent fuel assemblies, plus temporary storage for new fuel assemblies." *See* Attachment 2. These presentations underline the non-conservative nature of the Draft EIS' assumptions regarding pool capacity and the length of time the fuel will remain in the SMR pool.

d. Assumption that 10-Mile EPZ would be evacuated is not conservative.

The Draft EIS is not conservative because it does not address the environmental impacts of a pool fire if the ten-mile emergency planning zone ("EPZ") required by NRC regulations is cut back to two miles or the site boundary, as has been requested by TVA in Part 6 of its COL application. The studies on which the NRC relies for the Draft EIS assume the ten-mile EPZ is evacuated. *See, e.g.,* Spent Fuel Pool Study at x, 155.[2] The only exception is NUREG-1738, whose purpose was to determine whether the requirements for emergency planning in a ten-mile EPZ could safely be relaxed for decommissioning LWRs. NUREG-1738 showed that differences in accident consequences could be significant between evacuated and non-evacuated EPZs, depending on how soon after reactor shutdown the accident occurs. *See* Table 3.7-1, which shows that for a high ruthenium pool accident occurring within 30 days after discharge of fuel, evacuation of the EPZ could reduce the number of early fatalities from 192 to seven. This difference is significant and warrants examination in the Draft EIS, just as the NRC Staff did for reactor accidents. *See* note 2 above.

3. Demonstration that the Contention is Within the Scope of the Proceeding: This contention is within the scope of this ESP proceeding because it seeks consideration of the consequences of a type of severe accident that NRC views as reasonably foreseeable and therefore must address in the EIS for the proposed ESP.

---

[2] In contrast, for reactor core melt accidents, the NRC evaluated a range of scenarios, including evacuation of a ten-mile EPZ, evacuation of a two-mile EPA, and evacuation of a site-boundary EPZ. *Id.* at 5-74 – 5-75.

4. Demonstration that the Contention is Material to the Findings NRC Must Make to issue an ESP for the proposed TVA SMR: The contention is material to the findings that NRC must make in order to issue an ESP for the proposed TVA SMR because it relates to the question of whether the Draft EIS has addressed all reasonably foreseeable impacts of operating an SMR in its Environmental Report, as required by NEPA. *State of New York,* 681 F.3d at 483.

5. Concise Statement of the Facts or Expert Opinion Supporting the Contention, Along With Appropriate Citations to Supporting Scientific or Factual Materials: The facts supporting this contention, and the citations relied on by Intervenors, are stated above. In addition, Intervenors rely on the attached Declaration of Dr. Edwin J. Lyman (May 21, 2018). *See* Attachment 3.

New Contention 5 – Impermissible Discussion of Energy Alternatives and Need for the Proposed SMR

1. Statement of Contention:

The Draft EIS violates NEPA and NRC implementing regulations 10 C.F.R. §§ 51.75(b), 51.20(b), 51.104, and 52.21, by impermissibly incorporating and claiming to be "informed by" assertions by TVA regarding the economic, technical, and other benefits of the proposed SMR, including need for power and alternative energy sources. *See* Section 1.3 at 1-9 – 1-10. The Draft EIS also violates these NEPA regulations by presenting the "no-action" alternative as foregoing benefits (including the asserted benefits of operating the SMRs) rather than avoiding environmental impacts. *Id.* at xxxiii, 1-12, 9-2.

Because TVA elected not to address the need for power and energy alternatives in its Environmental Report, CLI-18-05, slip op. at 15, discussion of the benefits associated with *building and operating* the SMR is prohibited from the Draft EIS by Section 51.57(b). By the same token, the Draft EIS' inclusion of construction and operation-related benefits in its

"Purpose and Need" statement (Draft EIS at 1-9 – 1-10) goes far beyond the siting related benefits that are may be listed under 10 C.F.R. § 51.75(b) and the Commission's supporting rationale. Final Rule: Licenses, Certifications, and Approvals for Nuclear Power Plants, 72 Fed. Reg. 49,352, 49,430 (Aug. 28, 2007).

In addition, by incorporating TVA's assertions regarding the construction and operation-related benefits of the proposed SMR, at the same time as it claims *not* to have evaluated the need for power and energy alternatives, the NRC Staff raises a strong inference that it has included TVA's information in the Draft EIS without conducting its own independent evaluation, in violation of 10 C.F.R. § 51.70.

Finally, Intervenors contend that the Draft EIS' assertions regarding the need for the proposed SMR and the benefits of the proposed SMR in relation to other energy alternatives are not supported, adequately analyzed, or valid. Yet, Intervenors are prohibited by 10 C.F.R. § 52.21 from challenging the assertions as a result of TVA's and the NRC Staff's formal claims not to have addressed them in the Draft EIS. Intervenors respectfully submit that the NRC would violate NEPA's public participation requirements by including and claiming to rely on technical information in the Draft EIS, without permitting interested members of the public an opportunity to challenge the reliability of that information in a hearing. 10 C.F.R. §51.104.

2. Basis statement:

a. Requirements of NEPA

NEPA implements a "broad national commitment to protecting and promoting environmental quality." *Louisiana Energy Services, L.P.* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77, 87 (1998) (quoting *Robertson v. Methow Valley Citizens Council,* 490 U.S. 332, 348 (1989) and citing 42 U.S.C. § 4331). NEPA has two key purposes: to ensure that the

agency "will have available, and will carefully consider, detailed information concerning significant environmental impacts" before it makes a decision; and to guarantee that "the relevant information will be made available to the larger audience that may also play a role in the decision-making process and implementation of that decision." *Robertson*, 490 U.S. at 349.

In fulfilling NEPA's first purpose of evaluating the environmental impacts of its decisions, a federal agency is required to take a "hard look" at potential environmental consequences by preparing an EIS prior to any "major Federal action[] significantly affecting the quality of the human environment." *Robertson,* 490 U.S. at 349; 42 U.S.C. § 4332(c). The "hallmarks of a 'hard look' are thorough investigation into environmental impacts and forthright acknowledgment of potential environmental harms." *National Audubon Society v. Dept. of the Navy,* 422 F.3d 174, 185 (4th Cir. 2005). In addition, the agency must "rigorously explore and objectively evaluate the projected environmental impacts of all reasonable alternatives for completing the proposed action." *Van Ee v. EPA*, 202 F.3d 296, 309 (D.C. Cir. 2000). In considering alternatives, the agency must examine the "alternative of no action." 40 C.F.R. § 1502.14.

In fulfilling NEPA's second purpose of public participation, the agency's environmental analysis must be published for public comment "to permit the public a role in the agency's decision-making process." *Robertson,* 490 U.S. at 349-50; *Hughes River Watershed Conservancy v. Glickman,* 81 F.3d 437, 443 (4th Cir. 1996). NRC's Part 51 regulations also allow interested members of the public to participate in the environmental decision-making process through the NRC's hearing process. 10 C.F.R. §51.104.

In order for an EIS to serve its functions of informing decisionmakers and the public, it is essential that the EIS not be based on misleading assumptions. *Hughes River Watershed*

Conservancy, 81 F.3d at 446 (rejecting EIS that contained misleading projections of a project's economic benefits). Misleading assumptions "can defeat the first function of an EIS by impairing the agency's consideration of the adverse environmental effects of a proposed project," and the second function by "skewing the public's evaluation of a project." *Id*. (*citing South Louisiana Environmental Council, Inc. v. Sand,* 629 F.2d 1005, 1011-12 (5th Cir. 1980)).

b. Regulatory requirements for NEPA compliance in ESP proceedings

Because an ESP approves only the banking of a site and not construction or operation of any nuclear facility, the NRC allows the applicant to defer consideration of the relative costs and benefits of construction and operation, need for power, and energy alternatives. 10 C.F.R. § 51.50(b)(2). If an applicant elects to postpone consideration of these issues, NRC regulations limit the discussion of alternatives and benefits in the EIS to issues related to the siting of the facility:

> The draft environmental impact statement must not include an assessment of the economic, technical, or other benefits (for example, need for power) and costs of the proposed action or an evaluation of alternative energy sources, unless these matters are addressed in the early site permit environmental report.

10 C.F.R. § 51.75(b). As explained by the Commission, the focus of a NEPA review at the ESP stage is limited to siting issues unless the applicant explicitly chooses to conduct a broader analysis:

> Section 51.75 requires that the draft environmental impact statement must include an evaluation of alternative sites to determine whether there is any obviously superior alternative to the site proposed. *The draft environmental impact statement must also include an evaluation of the environmental effects of construction and operation of a reactor, or reactors, which have design characteristics that fall within the site characteristics and design parameters for the early site permit application, but only to the extent addressed in the early site permit environmental report or otherwise necessary to determine whether there is any obviously superior alternative to the site proposed.* The purpose of this change is to clearly delineate that the scope of the environmental review at the early site permit stage is, at a minimum, to address all issues needed for the NRC to perform its evaluation of the alternative sites. In addition, the applicant may choose to

> address one or more issues related to construction and operation of the facility with the goal of achieving finality on those issues at the early site permit stage.

72 Fed. Reg. at 49,432-33 (emphasis added). Thus, *only if the applicant chooses to address the economic and technical benefits of construction and operation in its Environmental Report* may those issues be addressed in the EIS for an ESP.

A corollary to the prohibition against discussion of need for power and energy alternatives is the requirement that an EIS at the ESP stage must describe the "proposed action" and "purpose and need" in relation to the siting decision, not construction and operation of a reactor. As explained in the preamble to the 2007 Part 52 regulations:

> *The environmental report and EIS for an early site permit must address the benefits associated with issuance of the early site permit (e.g., early resolution of siting issues, early resolution of issues on the environmental impacts of construction and operation of a reactor(s) that fall within the site characteristics, and ability of potential nuclear power plant licensees to ''bank'' sites on which nuclear power plants could be located without obtaining a full construction permit or combined license).* The benefits (and impacts) of issuing an early site permit must always be addressed in the environmental report and EIS for an early site permit, regardless of whether the early site permit applicant chooses to defer consideration of the benefits associated with the construction and operation of a nuclear power plant that may be located at the early site permit site. This is because the ''benefits * * * of the proposed action'' for which the discussion may be deferred are the benefits associated with the construction and operation of a nuclear power plant that may be located at the early site permit site; the benefits which may be deferred are entirely separate from the benefits of issuing an early site permit. *The proposed action of issuing an early site permit is not the same as the ''proposed action'' of constructing and operating a nuclear power plant for which the discussion of benefits (including need for power) may be deferred under § 51.50(b).*

Final Rule: Licenses, Certifications, and Approvals for Nuclear Power Plants, 72 Fed. Reg. at 49,430.

c. Environmental Report and Draft EIS

As noted by the Commission in CLI-18-05, TVA opted not to address alternative energy sources and need for power in its Environmental Report, as permitted by 10 C.F.R. § 51.50(b)(2). *Id.,* slip op. at 15. Nevertheless, TVA's Environmental Report included discussions

of the need for the proposed SMR and the alleged preferability of SMR technology from the standpoints of security, reliability, and environmental protection. *See id.,* Chapters 1 and 9. In Contention 3, SACE challenged the lawfulness of these assertions under the National Environmental Policy Act ("NEPA") and NRC implement regulations. Petition to Intervene and Request for Hearing at 11-24 (Jun. 12, 2017).

In October 2017, the ASLB admitted Intervenors' Contention 3. LBP-17-08, slip op. at 33. The Commission later reversed the admission of Contention 3, however, concluding that TVA's assertions regarding the need for power and energy alternatives were "extraneous" to "the determining factor" of TVA's explicit election "to defer a discussion of need for power and energy alternatives until the combined license application." *Id.,* slip op. at 15 (citing 10 C.F.R. § 51.50(b)(2)).

In April 2018, consistent with TVA's election to defer the discussion of need for power and energy alternatives under 10 C.F.R. § 51.50(b)(2), and as provided by 10 C.F.R. § 51.75(b)(2), the NRC Staff issued a Draft EIS stating that it "does not include an assessment of the need for power or energy alternatives." Draft EIS at 1-4. *See also id.* at 9-2 ("As stated in 10 CFR 51.50(b)(2) and 10 CFR 51.75(b) (TN250), the analysis of energy alternatives for the proposed TVA SMR project is not required for an ESP, was not addressed in the environmental report for the ESP application, and is therefore not addressed in this EIS.").

In Section 1.3, addressing the "Purpose and Need for the Proposed Action," the Draft EIS states that "[t]he primary purpose and need for the NRC proposed action (i.e., ESP issuance) is to provide for early resolution of site safety and environmental issues, which provides stability in the licensing process," This limited statement of purpose and need is consistent with the

Commission's regulatory framework for ESP environmental reviews, as set forth in the preamble to the 2007 Part 52 rulemaking. *See* discussion above at 18 and 72 Fed. Reg. at 49,430.

Despite having limited the "primary" purpose and need for issuance of the ESP to benefits of siting rather than construction, and despite having stated that the Draft EIS would not address need for power or energy alternatives, the Draft EIS goes on to assert that "[t]he NRC's purpose and need is further informed by the applicant's purpose and need," and incorporates five full paragraphs of text from TVA's Environmental Report. Draft EIS at 1-9 – 1-10. Each of these paragraphs contains TVA's rationalization, on various grounds, for the need to build and operate the proposed SMR and its alleged benefits compared to other energy alternatives. For instance, the Draft EIS quotes TVA's Environmental Report verbatim as follows:

> TVA proposes to deploy two or more SMRs with a maximum total electrical output of 800 megawatt electric (MWe) for the site, to demonstrate the capability of SMR technology. *SMRs provide the benefits of nuclear-generated power in situations where large nuclear units, with an approximate electrical output exceeding 1000 MWe, are not practical, because of transmission system constraints, limited space or water availability, or constraints on the availability of capital for construction and operation.*

Draft EIS at 1-9 (emphasis added). *Compare* Environmental Report at 1-1. Similarly, the Draft EIS quotes -- almost verbatim -- TVA's summary of the "four main objectives" of TVA's proposed SMR "Project," all of which relate to the need for the SMR and its alleged benefits as an energy alternative:

- Power generated by SMRs could be used for addressing critical energy security issues. Their use on or immediately adjacent to DoD or DOE [U.S. Department of Defense or U.S. Department of Energy] facilities, using robust transmission (e.g., armored transformers, underground transmission), could address national security needs by providing reliable electric power in the event of a major grid disruption. A more reliable electric power supply could be accomplished by the SMR operation in "power island" mode with robust transmission to critical facilities. In addition, intentional destructive acts (e.g., terrorist attacks) and natural phenomena (e.g., tornadoes, floods, etc.) could disrupt the grid and the ability to restore most generation sources. SMRs can provide reliable energy for extended operation.

Because nuclear reactors require fuel replenishment less frequently than other power generation sources (coal, gas, wind and solar), SMRs are less vulnerable to interruptions of fuel supply and delivery systems. TVA could demonstrate this "power islanding" and secure supply concept as part of the CR SMR project by utilizing controls, switching, and transmission capabilities to disconnect the SMR power plant from the electrical grid, while maintaining power from the SMR power plant to a specified DOE facility supplying reliable power that is less vulnerable to disruption from intentional destructive acts and natural phenomena.

- SMR technology can assist Federal facilities with meeting carbon reduction objectives. Energy-related carbon dioxide (CO2) emissions account for more than 80 percent of greenhouse gas (GHG) emissions in the United States. Studies show that on average coal combustion generates approximately 894–975 grams of CO2 per kilowatt-hour (g/kWh) of electricity generated. Natural gas generates an estimated 450–519 g/kWh. Nuclear power emission rates have been calculated to range from 6–26 g/kWh. [Citations in ER text omitted.]

- SMR design features include underground containment and inherent safe shutdown features, longer station blackout coping time without external intervention, and core and spent fuel pool cooling without the need for active heat removal. These key features advance safety by eliminating several design basis accident scenarios. Development of a security-informed design efficiently provides the same or better protection against the threats [operators of] large reactors must consider. Physical security is designed into the SMR plant architecture, incorporating lessons learned from significant shifts in security posture since 2001, and the opportunity to build more inherently secure features into the initial design.

- SMR power generating facilities are designed to be deployed in an incremental fashion to meet the power generation needs of a service area. Generating capacity can be added in increments to match load growth projections. For the CR SMR project, two or more SMRs would be constructed and brought into operation incrementally to achieve [a capacity of] up to 800 MW(e).

Id. at 1-9 – 1-10. *Compare* Environmental Report at 1-2 – 1-3.

Based on these asserted benefits of building and operating the SMR, the Draft EIS concludes that "[t]he NRC's purpose and need is informed by the applicant's objective to use the power generated by SMRs to address critical energy security issues for TVA Federal direct-served customers (which included only DoD or DOE facilities)." *Id.* at 1-10.

The Draft EIS also compares the SMR favorably to the no-action alternative by characterizing it as an action that would forego benefits rather than avoid adverse impacts:

> In the no-action alternative, the action would not go forward. The NRC could deny the TVA request for an ESP. The no-action or permit denial alternative also is available to the USACE [United State Army Corps of Engineers] after a permit is submitted to the USACE. The no-action alternative is one that results in no activities requiring a USACE permit. It may be brought by (1) the applicant electing to modify his proposal to eliminate work under the jurisdiction of the USACE or (2) the denial of the permit. If the request and/or permit were denied, the construction and operation of a new nuclear power plant at the proposed CRN Site in accordance with the 10 CFR Part 52 (TN251) process referencing an approved ESP would not occur, *nor would any benefits intended by an approved ESP be realized.*

Draft EIS at 1-12 (emphasis added). Similarly, the Draft EIS states in Section 9.1 (No Action Alternative):

> [T]he no-action alternative would accomplish none of the benefits intended by the ESP process, which would include (1) early resolution of siting issues prior to large investments of financial capital and human resources in new plant design and construction, (2) early resolution of issues related to the environmental impacts of construction and *operation of new nuclear units that fall within the plant parameters for small modular reactor (SMR) nuclear generating units.*

Id. at 9-1 (emphasis added).

d. The Draft EIS' discussion of energy alternatives and the need for the proposed SMR violates NEPA and NRC implementing regulations.

As discussed above, because TVA elected, pursuant to 10 C.F.R. § 51.50(b)(2), not to address the need for power and alternative energy sources in its Environmental Report, 10 C.F.R. § 51.75(b) prohibits the NRC Staff from discussing these topics in the Draft EIS. The Draft EIS violates that prohibition by reproducing and claiming to be "informed" by TVA's one-sided assertions regarding the need for and comparative benefits of the proposed SMRs as an energy source. Draft EIS at 1-9 – 1-10. By presenting these rationalizations for the construction and operation of the proposed SMR, the NRC Staff violates both the plain language of 10 C.F.R. § 51.75 and the Commission's regulatory framework for an EIS prepared at the ESP stage, which requires the EIS to focus on siting issues only. 72 Fed. Reg. 49,432-33. *See also Exelon Generation Co., L.L.C.* (Early Site Permit for Clinton ESP Site), *et al.,* CLI-05-17, 62 NRC 5, 48

(2005) (observing that at the ESP stage, "boards must merely weigh and compare alternative sites, not other types of alternatives (such as alternative energy sources.").

By the same token, the Draft EIS' discussion of the no-action violates 10 C.F.R. § 51.75(b) and its underlying principles, by presenting the effects of the "no-action" alternative as foregoing benefits that include operating the SMRs. *See Draft EIS.* at xxxiii, 1-12, 9-2. As the Commission observed in the 2007 rulemaking for new reactor licensing, the "benefits which may be deferred [*i.e.,* the benefits of operating a reactor] are "entirely separate from the benefits of issuing at early site permit." 72 Fed. Reg. at 49,430. The regulations therefore preclude the Draft EIS from discussing the operation of the SMR as a foregone benefit of the no-action alternative.

The Draft EIS also violates NEPA's requirement for NRC's independence from TVA in the NEPA process, as set forth in in 10 C.F.R. § 51.70(b). Section 51.70(b) provides that "[t]he NRC staff will independently evaluate and be responsible for the reliability of all information used in the draft environmental impact statement." As discussed above, the Staff has elected *not* to conduct an independent inquiry into the need for proposed SMR or energy alternatives at the ESP stage; yet the Draft EIS quotes and claims to be "informed by" extensive assertions by TVA regarding the comparative benefits of the proposed SMR as an energy alternative. Draft EIS at 1-9- - 1-10.

By incorporating and claiming to be informed by TVA's assertions regarding the construction and operation-related benefits of the proposed SMR, at the same time as it claims *not* to have evaluated the need for power and energy alternatives, the NRC Staff raises a strong inference that it has included and used TVA's information in the Draft EIS without conducting its own independent evaluation, in violation of 10 C.F.R. § 51.70(b). The use in the Draft EIS of assertions that have not been independently verified by the NRC Staff violates 10 C.F.R. §

51.70(b). In addition, the Staff's implicit endorsement of TVA's assertions has the potential to violate NEPA by misleading the public into thinking the NRC has an independent basis to deem the information reliable, thereby impermissibly "skewing the public's evaluation of [the] project." *Hughes River Watershed Conservancy*, 81 F.3d at 446. Given the lack of an independent staff analysis of TVA's claims, and given the errors in these claims, these assertions should not be permitted in the final EIS.

In addition, the Draft EIS violates NEPA's public participation requirements by making unsupported, unverified, and demonstrably inaccurate factual claims that are not subject to challenge in this proceeding. 10 C.F.R. § 52.21. *See also Robertson*, 490 U.S. at 349 (noting NEPA's intention for the public to play a role "in the decision-making process and implementation of that decision."). By making claims in the Draft EIS that are insulated from challenge in this proceeding by § 52.21, the NRC Staff prevents Intervenors from fulfilling their right under 10 C.F.R. § 51.104(a)(2) to "take a position and offer evidence" on the adequacy of the EIS with respect to those statements. As demonstrated below in Section 2.d., Intervenors dispute the Draft EIS' claims regarding the need for power and energy alternatives, which are not supported, thoroughly analyzed, or valid.

e. The Draft EIS' claims regarding the benefits of the proposed SMR are not supported or valid.

The claims in the Draft EIS regarding the benefits of the proposed SMR are not supported, thoroughly analyzed, or valid. Therefore, even aside from the illegality of those claims under 10 C.F.R. § 51.75(b), they should not be permitted to remain in the Draft EIS. If Intervenors were not precluded from challenging these claims under 10 C.F.R. § 51.21, they would contest the claims in contentions in this proceeding, on many grounds, including, but not limited to:

- The Draft EIS cites TVA's selective comparisons of SMRs with other energy technologies, but does not provide a comprehensive comparison. For instance, the Draft EIS compares SMRs with coal, gas, wind and solar on the factor of reliability. Draft EIS at 1-10. But it does not make a comprehensive analysis that addresses all relevant factors, such as carbon reduction, water use, air and water impacts, generation of waste products, and costs.
- The Draft EIS fails to acknowledge that solar and wind energy sources can meet all the other objectives listed by TVA (carbon reduction, safety, and incremental deployment), and have less deleterious environmental impacts, in particular, water use. In fact, based on Table 3.1-2 of the Environmental Report, which states that "[t]he expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water system" are "17,078 gpm (expected) [and] 25,608 gpm (maximum))," and assuming that TVA used a reactor capacity of 800 MW, the expected rate of water withdrawal translates to 1,281 gallons/MW/hour. That rate of water withdrawal is higher than almost any other form of electricity generation. A combined cycle natural gas plant will be about a factor of four lower.[3] Solar photovoltaics (PV) and wind use negligible amounts of water; PV plants, for example, use about one gallon/MW/hour.
- To the extent that the Draft EIS compares SMRs with other energy sources on the factor of reliability, the comparison makes only partial sense. The Draft EIS asserts that "[b]ecause nuclear reactors require fuel replenishment less frequently than other power generation sources (coal, gas, wind and solar), SMRs are less vulnerable to interruptions

[3] J. Macknick et al., *Operational water consumption and withdrawal factors for electricity generating technologies: a review of existing literature*, 7 ENVIRON. RES. LETT. 45802 (2012).

of fuel supply and delivery systems." *Id.* at 1-9 – 1-10. While the statement is true for coal and gas, it is irrational in the case of wind and solar because they need no fuel replenishment. Renewable sources of power like solar and wind are, therefore, not vulnerable to fuel disruption. Although these are intermittent in nature, that concern can be addressed in a number of ways, in particular by incorporating on-site energy storage technologies.

- The Draft EIS asserts that:

> Because nuclear reactors require fuel replenishment less frequently than other power generation sources (coal, gas, wind and solar), SMRs are less vulnerable to interruptions of fuel supply and delivery systems. TVA could demonstrate this "power islanding" and secure supply concept as part of the CR SMR project by utilizing controls, switching, and transmission capabilities to disconnect the SMR power plant from the electrical grid, while maintaining power from the SMR power plant to a specified DOE facility supplying reliable power that is less vulnerable to disruption from intentional destructive acts and natural phenomena.

Draft EIS at 1-10. But the Draft EIS lumps generation and transmission together, without justification. Reliance on SMR technology has nothing to do with the security of transmission systems. In addition, the Draft EIS fails to address the United States' history of unsuccessful experimentation with small reactors, which suggests that SMRs are quite unlikely to be reliable sources of generating power in the first place.[4] Prior experience that is particularly important to take note of is the Army's Nuclear Power Program, which was started in the 1950s, and resulted in the construction of eight small reactors. The experiences with these reactors reveal the potential for failure implicit with SMRs. The PM-3A reactor at McMurdo Sound in Antarctica, for example, "developed several

[4] M.V. Ramana, *The Forgotten History of Small Nuclear Reactors*, IEEE SPECTRUM, 2015, http://spectrum.ieee.org/energy/nuclear/the-forgotten-history-of-small-nuclear-reactors (last visited May 24, 2015); M. V. Ramana, *The checkered operational history of high temperature gas cooled reactors*, 72 BULLETIN OF THE ATOMIC SCIENTISTS 171–79 (2016).

malfunctions, including leaks in its primary system [and] cracks in the containment vessel that had to be welded."[5] The leaks from the plant resulted in significant contamination and nearly 14,000 tons of contaminated soil was physically removed and shipped to Port Hueneme, a naval base north of Los Angeles, for disposal. The Army eventually cancelled the program in 1976, due to poor economics as well as the realization that diesel generators were a superior option for supplying power to remote areas. The official history of the Army's Nuclear Power Program termed the development of small reactors "expensive and time consuming."[6]

- The Draft EIS asserts:

> SMR technology can assist federal facilities with meeting carbon reduction objectives. Energy-related carbon dioxide (CO2) emissions account for more than 80 percent of greenhouse gas (GHG) emissions in the United States. Studies show that on average coal combustion generates approximately 894-975 grams of CO2 per kilowatt-hour (g/kWh) of electricity generated. Natural gas generates an estimated 450-519 g/kWh. Nuclear power emission rates have been calculated to range from 6 - 26 g/kWh.

Id. at 1-10. The Draft EIS' unsupported assertion that nuclear power emission rates have been calculated to range from 6 to 26 grams per kilowatt hour is erroneous in two key respects. First, independent studies suggest that there is much uncertainty about the level of emissions associated with the generation of nuclear energy. A widely cited academic study shows that estimates of lifecycle emissions from nuclear power plants vary by over two orders of magnitude, from 1.4 to 288 g/kWh of CO2, with a mean value of 66 g/kWh.[7] Second, and more important, SMRs require more uranium fuel for each kWh of

[5] LAWRENCE H. SUID, THE ARMY'S NUCLEAR POWER PROGRAM: THE EVOLUTION OF A SUPPORT AGENCY 111 (1990).

[6] Suid, *supra,* at 93.

[7] Benjamin K. Sovacool, *Valuing the greenhouse gas emissions from nuclear power: A critical survey*, 36 ENERGY POLICY 2950–63 (2008).

electricity generated.[8] Because of their smaller size and higher area to volume ratio, SMRs will necessarily leak more neutrons from the core when compared to larger reactors. As a result, SMRs need more fuel for each kWh of electricity generated in comparison to the large LWRs that are most common around the world, and that are the basis for the emission estimates made so far (either the 6-26 g/kWh or the 1.4-288 g/kWh). Emissions of CO2 associated with uranium mining, processing, and enrichment are the dominant contributions to the lifecycle emissions associated with nuclear power. Therefore, this increased need for fuel would result in a corresponding increase in the CO2 emissions per kWh.

- The Draft EIS claims that TVA's SMR design improves on spent fuel pool safety by providing for "spent fuel pool cooling without the need for active heat removal." Draft EIS at 1-10. But this assertion does not mention other relevant information demonstrating that SMRs may require greater spent fuel storage capacity than LWRs, because they could generate a larger quantity of spent fuel for each kWh of electricity generated – additional impacts that should be compared with the safety benefits claimed by TVA. *See, e.g.,* Glaser et al., cited in note 8 above. For instance, TVA's calculations in its Environmental Report appear to use a burnup value of 51 gigawatt-days per metric ton of uranium ("GWD/tU"). This value is much higher than some of the reported burnups of the designs of the four potential SMRs under consideration by TVA. For example, the International Atomic Energy Agency lists the burnup of the Holtec SMR design as 32

[8] Alexander Glaser, Laura Berzak Hopkins & M.V. Ramana, *Resource Requirements and Proliferation Risks Associated with Small Modular Reactors*, 184 NUCLEAR TECHNOLOGY 121–29 (2013).

GWD/tU.[9] At this relatively low burnup, the Holtec SMR will generate more spent fuel than an SMR design that has a burnup of 51 GWD/tU. In turn, this would mean that the fuel pool capacity and, possibly, dry storage capacity, will have to be increased.

This is only a partial list of deficiencies in the Draft EIS' discussion of need for the proposed SMR and energy alternatives, which Intervenors are precluded from raising in this hearing by 10 C.F.R. § 52.20. It would be extremely unfair to allow these statements to remain in the EIS, when Intervenors have been prevented from challenging their veracity in this proceeding.

3. Demonstration that the Contention is Within the Scope of the Proceeding: This contention is within the scope of this ESP proceeding because it seeks compliance with NEPA and NRC regulations for the implementation of NEPA in the EIS for the proposed SMR.

4. Demonstration that the Contention is Material to the Findings NRC Must Make to issue an ESP for the proposed TVA SMR: The contention is material to the findings that NRC must make in order to issue an ESP for the proposed TVA SMR because it relates to the question of whether the NRC's Draft EIS improperly addresses issues that are prohibited from inclusion in the Draft EIS, whether the statements in the Draft EIS regarding the technical and operational benefits of the proposed SMR have been independently verified, and whether Intervenors have been unfairly deprived of a hearing on unsupported and incorrect assertions in the Draft EIS.

5. Concise Statement of the Facts or Expert Opinion Supporting the Contention, Along With Appropriate Citations to Supporting Scientific or Factual Materials: The facts and expert opinion supporting this contention, and the citations relied on by Petitioners, are

[9] IAEA, ADVANCES IN SMALL MODULAR REACTOR TECHNOLOGY DEVELOPMENTS 89 (2014).

stated above. This contention is supported by the attached declaration of Dr. M.V. Ramana. *See* Attachment 4.

IV. INTERVENORS HAVE GOOD CAUSE TO FILE THIS MOTION AFTER THE INITIAL DEADLINE FOR HEARING REQUESTS.

Intervenors satisfy the three requirements of 10 C.F.R. § 2.309(c) for establishing good cause to file Contentions 4 and 5 after the initial 2017 deadline for filing hearing requests on the proposed ESP. First, the information on which Contentions 4 and 5 is based "was not previously available." 10 C.F.R. § 2.309(c)(1)(i). As discussed above in Section II, TVA's Environmental Report did not contain any analysis of pool fire impacts, and Intervenors' original Contention 2 was a contention of omission. The Draft EIS provides the first environmental analysis of spent fuel pool impacts that has been published in this proceeding.

Nor was the information on which Contention 5 is based previously available. The regulations on which Contention 5 is based – 10 C.F.R. §§ 51.75(b), 51.20(b), 51.104, and 52.21 – apply to the Draft EIS, not TVA's Environmental Report. Until the NRC published the Draft EIS, Intervenors had no way of knowing whether the NRC Staff would comply with these regulations.

Second, the information upon which Contentions 4 and 5 is based is "materially different" from the information that was previously available. 10 C.F.R. § 2.309(c)(1)(ii). No spent fuel pool impact analysis for the TVA SMR pool had been published prior to issuance of the Draft EIS, and therefore it is materially different from what was previously provided. With respect to Contention 5, the information is materially different because it concerns compliance by NRC Staff with a completely different set of regulations than were applicable to the TVA SMR.

Finally, this motion has been submitted in a "timely fashion based on the availability of the subsequent information." The Draft EIS was posted on ADAMS April 20, 2018, and this motion is being filed within 30 days. *See* Initial Scheduling Order at 4 (Dec. 7, 2017).

V. CONSULTATION PURSUANT TO 10 C.F.R. § 3.232

Although 10 C.F.R. § 2.309(c)(2)(i) appears to excuse Intervenors from consulting opposing counsel regarding this motion, Intervenors' counsel consulted them in an abundance of caution. Counsel for both TVA and the NRC Staff stated they would oppose the motion.

VI. CONCLUSION

For the foregoing reasons, Intervenors' Contentions 4 and 5 should be admitted to this proceeding.

Respectfully submitted,

___/signed electronically by/__

Diane Curran
Harmon, Curran, Spielberg, & Eisenberg, L.L.P.
1725 DeSales Street N.W., Suite 500
Washington, D.C. 20036
240-393-9285
dcurran@harmoncurran.com

May 21, 2018

CERTIFICATE OF SERVICE

I certify that on May 21, 2018, I posted copies of the foregoing INTERVENORS' MOTION FOR LEAVE TO FILE CONTENTION 4 (INADEQUATE DISCUSSION OF ENVIRONMENTAL IMPACTS OF SPENT FUEL POOL FIRES) AND CONTENTION 5 (IMPERMISSIBLE DISCUSSION OF ENERGY ALTERNATIVES AND NEED FOR THE PROPOSED SMR) and Attachments 1, 2, 3 and 4, on the NRC's Electronic Information Exchange System.

___/signed electronically by/__

Diane Curran
Harmon, Curran, Spielberg, & Eisenberg, L.L.P.
1725 DeSales Street N.W., Suite 500
Washington, D.C. 20036
240-393-9285
dcurran@harmoncurran.com

Attachment 1

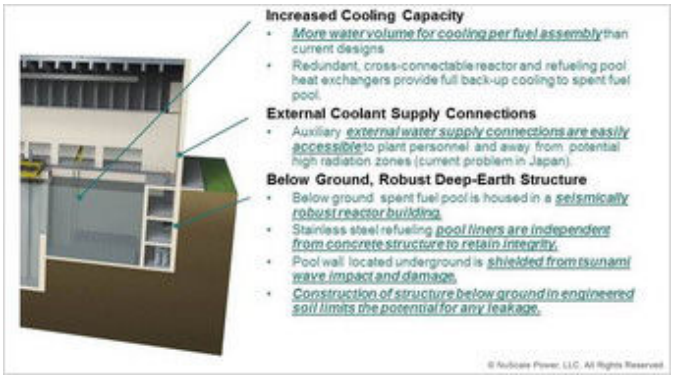
The NuScale spent fuel pool provides storage for up to 10 years of spent fuel storage, plus temporary storage for new fuel assemblies. The pool water volume provides a minimum of 30 days of passive cooling of the spent fuel assemblies following a loss of all electrical power without the need for additional water.

The NuScale spent fuel pool is a below-grade, stainless steel lined concrete pool adjacent to the reactor pool. The stainless steel liner is seismically isolated from the concrete pool wall. Its below-grade position greatly reduces potential for loss of

The NuScale spent fuel pool and dry cask storage can safely store all of the spent fuel from 60 years of operations.

cooling water. A clean-up system reduces the build-up of contaminants.

After removal from the reactor core, spent fuel assemblies are placed in dedicated spent fuel storage racks in the below ground spent fuel pool, which contains four times more water volume for cooling per fuel assembly than current designs. Use of standard LWR fuel allows leveraging extensive experience and infrastructure for the storage, handling, and shipment of spent reactor fuel. Our facility is designed for ease of spent fuel transfer to a dry cask storage system. Within approximately 5 years, the thermal load of the spent fuel assemblies is reduced significantly, and can be moved to a secure dry storage area. The plant site layout includes space allocation adequate for the dry storage of all of the spent fuel for the 60-year life of the plant.



Spent Fuel Storage

More about NuScale's protection against extreme events to safeguard the public, workers, and the environment.

Attachment 2

Safety Features of the NuScale Design

In designing the NuScale Power Module™ and power plant, NuScale has achieved a paradigm shift in the level of safety of a nuclear power plant facility. It is a revolutionary solution to one of the biggest technical challenges for the current fleet of nuclear energy facilities.

NuScale's innovative and comprehensive safety features are incorporated to provide stable long-term nuclear core cooling under all conditions, including severe accidents. These safety features include:

NuScale has achieved a breakthrough in the safety of a nuclear power plant, using simple passive systems to provide stable long-term, nuclear core cooling under all conditions, including severe accidents.

The Triple Crown For Nuclear Plant Safety™

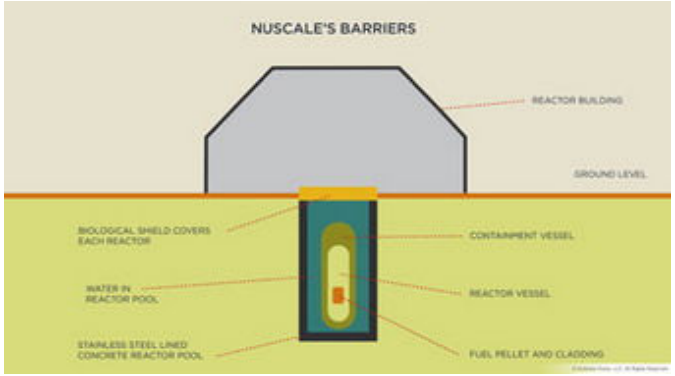
design safely shuts down and self-cools, indefinitely with no operator action, no AC or DC power, and no additional water.

High-pressure containment vessel, redundant passive decay heat removal, and containment heat removal systems.

The integrated design of the NuScale Power Module, encompassing the reactor, steam generators, and pressurizer, and its use of natural circulation eliminates the need for large primary piping and reactor coolant pumps.

A small nuclear fuel inventory, since each 50 MWe (gross) NuScale Power Module houses approximately 5% of the nuclear fuel of a conventional 1,000 MWe nuclear reactor.

Containment vessel submerged in an ultimate heat sink for core cooling in a below grade reactor pool structure housed in a Seismic Category 1 reactor building.



Protection Against Extreme Events

Triple Crown for Nuclear Plant Safety™

NuScale has developed a safety system that does not require DC batteries to place the

Reactor Buildings & Barriers

The reactor building is a Seismic Category 1 reinforced concrete structure designed to withstand the effects of aircraft impact, environmental conditions, natural phenomena,

plant in a safe cool-down condition following an extreme event.

Reactor Modules

Each NuScale Power Module incorporates simple, redundant, diverse, and independent safety features.

Protection Against Extreme Events

NuScale's Power Module and power plant are designed to protect the environment against extreme events.

postulated design basis accidents, and design basis threats.

Spent Fuel Pool

The spent fuel pool provides storage space for up to 15 years of accumulated spent fuel assemblies, plus temporary storage for new fuel assemblies.

Rightsizing the EPZ

The NuScale SMR design allows for an EPZ that is significantly smaller than conventional nuclear plants.

Attachment 3

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 52-047-ESP
Tennessee Valley Authority	)	
	)	
(Clinch River Nuclear Site)	)	
	)	

DECLARATION OF DR. EDWIN S. LYMAN IN SUPPORT OF INTERVENORS' CONTENTION 4 (INADEQUATE DISCUSSION OF ENVIRONMENTAL IMPACTS OF POOL FIRES)

Under penalty of perjury, Edwin S. Lyman declares as follows:

1. My name is Edwin S. Lyman. I am a Senior Staff Scientist at the Union of Concerned Scientists.

2. I am a qualified expert on matters relating to nuclear power plant safety and security. I earned a doctorate in physics from Cornell University in 1992. From 1992 to 1995, I was a postdoctoral research associate at Princeton University's Center for Energy and Environmental Studies (now the Science and Global Security Program), where my research focused on the prevention of nuclear proliferation, nuclear and radiological terrorism, and nuclear accidents. I have published articles and letters regarding those issues in journals and magazines including *Science*, *Nature*, *The Bulletin of the Atomic Scientists*, *Science and Global Security*, *Arms Control Today*, *Nuclear Engineering International*, *New Scientist* and *Energy and Environmental Science*. I am a co-author (with David Lochbaum and Susan Q. Stranahan) of the book *Fukushima: The Story of a Nuclear Disaster* (The New Press, 2014).

3. I have considerable experience and expertise with respect to the issue of spent fuel pool fire risks, and have briefed both the NRC and the National Academy of Sciences on issues related to pool fire risks. In addition, I am a co-author of the article "Nuclear Safety Regulation in the Post-Fukushima Era," which was published in *Science* magazine on May 26th, 2017 and focuses on spent fuel pool fire risks. A copy of my curriculum vitae is attached.

4. I am familiar with the licensing-related filings and correspondence that have been submitted by Tennessee Valley Authority ("TVA") in support of its application for an Early Site Permit ("ESP") for a Small Modular Reactor ("SMR") on the Clinch River Nuclear Site. I am also familiar with the Draft Environmental Impact Statement prepared by the U.S. Nuclear Regulatory Commission ("NRC") for the proposed ESP. NUREG-2226, Draft Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site (April 2018) ("Draft EIS"). And I am familiar with applicable NRC

regulations, policies, and guidance documents.

5. I assisted Intervenors with the preparation of their Contention 4, which challenges the adequacy of the Draft EIS' discussion of spent fuel pool fire risks to satisfy the National Environmental Policy Act ("NEPA"). The factual assertions in the contention are true and correct to the best of my knowledge, and the opinions expressed therein are based on my best professional judgment.

Edwin S. Lyman, Ph.D.

May 21, 2018

Edwin Stuart Lyman
Curriculum Vitæ

Education

Ph.D, Cornell University, Theoretical Physics, August 1992.
M.S., Cornell University, Physics, January 1990.
A.B., *summa cum laude*, New York University, Physics, June 1986; Phi Beta Kappa.

Professional Experience

May 1, 2003 – Present: Senior Scientist, Union of Concerned Scientists.

Spring 2015: Adjunct Professor, Elliott School of International Affairs, The George Washington University, Washington, DC. Taught Master's level course on nuclear energy.

June 2002 – April 2003: President, Nuclear Control Institute, Washington, D.C.

July 1995 – May 2002: Scientific Director, Nuclear Control Institute, Washington, D.C.

August 1992 – June 1995: Postdoctoral research associate, Center for Energy and Environmental Studies, Princeton University, Princeton, NJ.

Spring 1995: Preceptor for Environmental Studies 302, "Perspectives on Environmental Issues: Values and Policies."

Spring 1994: Lecturer, Woodrow Wilson School. Preceptor for WWS 304, "Science, Technology and Public Policy."

July 1988 – June 1992: Graduate research assistant, Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, NY. Conducted thesis research on high-energy physics under the supervision of Prof. S.H.-H. Tye.

August 1986–June 1988: Andrew D. White Graduate Fellow, Physics, Cornell University.

Other

Active Nuclear Regulatory Commission "L" clearance

Books and Book Chapters

D. Lochbaum, E. Lyman and S.Q. Stranahan, *Fukushima: The Story of a Nuclear Disaster.* The New Press, New York, 2014.

E. Lyman," Nuclear Energy and Human Health," Encyclopedia of Environmental Health, Elsevier Science, 2011.

E. Lyman, "Can Nuclear Fuel Production in Iran and Elsewhere be Safeguarded Against Diversion?" in *Falling Behind: International Scrutiny of the Peaceful Atom* (H.D. Sokolski, ed.), Strategic Studies Institute, U.S. Army War College, 2008, 101-120.

E. Lyman and D. Lochbaum, "Protecting Vital Targets: Nuclear Power Plants," in *Homeland Security: Protecting America's Targets, Vol. III* (J. Forest, ed.), Praeger, Westport, CT, 2006, 157-173.

E. Lyman, "The Limits of Technical Fixes," in *Nuclear Power and The Spread of Nuclear Weapons: Can We Have One Without the Other?*" (P. Leventhal, S. Tanzer and S. Dolley, eds.), Brassey's, Washington, DC, 2002, 167-182.

Journal Articles and Letters

E. Lyman, M. Schoeppner and F. von Hippel, "Nuclear Safety Regulation in the Post-Fukushima Era," *Science* **356** (2017), 808-809.

E. Lyman and F. von Hippel, "Nuclear Waste: Weapons Plutonium Riskier Above Ground" (letter), *Nature* **530** (2016), 281.

T. Clements, E. Lyman and F. von Hippel, "The Future of Plutonium Disposition," *Arms Control Today*, June/July 2013.

J. Beyea, E. Lyman and F. von Hippel, "Accounting for Long-Term Doses in "Worldwide Health Effects of the Fukushima Daiichi Nuclear Accident'," *Energy and Environmental Science* **6** (2013), 1042-1045.

E. Lyman, "Rotblat's Pursuit of Nuclear Peace," *New Scientist*, January 25, 2012.

E. Lyman, Surviving the One-Two Nuclear Punch. *Bulletin of the Atomic Scientists online,* September 2011.

E. Lyman, "Security Since September 11th, "*Nuclear Engineering International*, May 20, 2010.

E. Lyman, "Thirty Years after TMI: Five Continuing Vulnerabilities," *Bulletin of the Atomic Scientists*, March 23, 2009.

E. Lyman, "Making Domestically Produced Medical Isotopes a National Priority," *Bulletin of the Atomic Scientists*, December 18, 2008.

E. Lyman, “Can Nuclear Plants be Safer?” *Bulletin of the Atomic Scientists*, September/October 2008, 34-37.

E. Lyman and F. von Hippel, “Reprocessing Revisited: The International Dimensions of the Global Nuclear Energy Partnership,” *Arms Control Today*, April 2008, 6-14.

J. Beyea, E. Lyman and F. von Hippel, “Damages from a Major Release of ^{137}Cs Into the Atmosphere of the United States,” *Science and Global Security* **12** (2004) 125-136.

G. Bunn, C. Braun, A. Glaser, E. Lyman and F. Steinhausler, "Research Reactor Vulnerability to Sabotage by Terrorists," *Science and Global Security* **11** (2003) 85-107.

D. Hirsch, D. Lochbaum and E. Lyman, “The NRC’s Dirty Little Secret,” *Bulletin of the Atomic Scientists* (May/June 2003).

R. Alvarez, J. Beyea, K. Janberg, J. Kang, E. Lyman, A. Macfarlane, G. Thompson and F. von Hippel, “Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States,” *Science and Global Security* **11** (2003) 1-51.

E. Lyman, "Revisiting Nuclear Power Plant Safety" (letter), *Science* 299 (2003), 202.

E. Lyman, "The Pebble-Bed Modular Reactor: Safety Issues," *Physics and Society*, American Physical Society, October 2001.

E. Lyman, "Public Health Risks of Substituting Mixed-Oxide for Uranium Fuel in Pressurized Water Reactors," *Science and Global Security* **9** (2001), 1.

E. Lyman and S. Dolley, "Accident Prone," *Bulletin of the Atomic Scientists*, March/April 2000, 42.

E. Lyman and H. Feiveson, "The Proliferation Risks of Plutonium Mines," *Science and Global Security* **7** (1998), 119.

E. Lyman and P. Leventhal, "Bury the Stuff [Weapons Plutonium]," *Bulletin of the Atomic Scientists*, March/April 1997, 45.

E. Lyman, "Weapons Plutonium: Just Can It," *Bulletin of the Atomic Scientists*, November/December 1996, 48.

F. von Hippel and E. Lyman, "Appendix: Probabilities of Different Yields," addendum to J. Mark, "Explosive Properties of Reactor-Grade Plutonium," *Science and Global Security* **4** (1993), 125.

F. Berkhout, A. Diakov, H. Feiveson, H. Hunt, E. Lyman, M. Miller, and F. von Hippel, "Disposition of Separated Plutonium," *Science and Global Security* **3** (1993), 161

E. Lyman, F. Berkhout and H. Feiveson, "Disposing of Weapons-Grade Plutonium," *Science* **261** (1993) 813.

P. Argyres, E. Lyman and S.H.-H. Tye, "Low-Lying States of the Six-Dimensional Fractional Superstring," *Phys. Rev*. D46 (1992) 4533.

S.-w. Chung, E. Lyman and S.H.-H. Tye, "Fractional Supersymmetry and Minimal Coset Models in Conformal Field Theory," *Int. J. Mod. Phys* A7 (1992) 3337.

Selected Reports

E. Lyman, "Preventing an American Fukushima," Union of Concerned Scientists, March 2016.

E. Lyman, "Excess Plutonium Disposition: The Failure of MOX and the Promise of Its Alternatives," Union of Concerned Scientists, December 2014.

E. Lyman, "Small Isn't Always Beautiful: Safety, Security and Cost Concerns About Small Modular Reactors," Union of Concerned Scientists, September 2013.

D. Lochbaum and E. Lyman, "U.S. Nuclear Power Safety One Year After Fukushima," Union of Concerned Scientists, March 2012.

L. Gronlund, D. Lochbaum and E. Lyman, "Nuclear Power in a Warming World," Union of Concerned Scientists, December 2007.

E. Lyman (with M. Schneider et al.), "Residual Risk: An Account of Events in Nuclear Power Plants Since the Chernobyl Accident in 2006," commissioned by the Greens of the European Parliament, May 2007.

E. Lyman, "Chernobyl on the Hudson? The Health and Environmental Impacts of a Terrorist Attack at the Indian Point Nuclear Power Plant," commissioned by Riverkeeper, Inc., September 2004.

E. Lyman, "Safety Issues in the Sea Shipment of Vitrified High-Level Radioactive Wastes to Japan," report sponsored by the Nuclear Control Institute, Greenpeace International and Citizens' Nuclear Information Center Tokyo, December 1994.

E. Lyman, "Interim Storage Matrices for Excess Plutonium: Approaching the 'Spent Fuel Standard' Without the Use of Reactors," PU/CEES Report No. 286, Center for Energy and Environmental Studies, Princeton University, August 1994.

E. Lyman, "The Solubility of Plutonium in Glass," PU/CEES Report No. 275, Center for Energy and Environmental Studies, Princeton University, April 1993.

Selected Invited Talks and Testimony

"Perspectives on Security Issues," presentation at NRC Commission closed briefing, June 23, 2016.

Testimony on advanced nuclear reactors before the Senate Committee on Environment and Public Works, Subcommittee on Clean Air and Nuclear Safety, April 21, 2016.

"Alternatives to MOX," presentation to the Savannah River Site Citizens' Advisory Board, Augusta, GA, March 29, 2016 (with Frank von Hippel)

"NRC's Fukushima Response: Lessons Learned and Lessons Unheeded," presentation at the NRC Regulatory Information Conference, March 10, 2016.

"Fixing the NRC's Broken Framework for Reducing Severe Accident Risk," presentation to the NRC Advisory Committee on Reactor Safeguards, December 1, 2015.

"UCS Perspectives on NRC and Industry Actions in Response to Fukushima," presentation at NRC Commission briefing, April 30, 2015.

"Perception versus Reality: UCS Views on Nuclear and Radiological Terrorism Risks," presentation at the Institute of Nuclear Materials Management "Reducing the Risk" Workshop, Washington, DC, March 17, 2015.

"Fukushima and its Lessons for Nuclear Safety," seminar at The Library of Congress, February 19, 2015.

"Production of Mo-99 Without the Use of Highly Enriched Uranium: Perspectives of the Union of Concerned Scientists," presentation to the National Academy of Sciences Committee on Status of Mo-99 Production, February 12, 2015.

"Safety and Security of Spent Fuel Storage in the United States," presentation to the National Academy of Sciences Fukushima Lessons Learned Panel, January 29, 2015.

"UCS Views on the NRC's Human Reliability Program Activities and Analyses," presentation at NRC Commission briefing, May 29, 2014.

"Public Confidence and Force-on-Force Inspections," presentation at the NRC Regulatory Information Conference, March 13, 2014.

"Fukushima: The Story of a Nuclear Disaster," lecture at the Carter Presidential Library, Atlanta,

GA, February 10, 2014.

"UCS Views on NTTF Recommendation 1 and the NRC Staff Proposal," presentation at NRC Commission briefing, January 10, 2014.

"UCS Perspective on Expedited Transfer of Spent Fuel to Dry Casks," presentation at NRC Commission briefing, January 6, 2014.

"Security Impacts of Emerging Nuclear Technologies," MITRE STEP Technical Exchange, McLean, VA, December 3, 2013.

"UCS Perspective on Considering Economic Consequences in the NRC's Regulatory Framework," presentation at NRC Commission briefing, September 11, 2012.

"Lessons from Fukushima for Improving Nuclear Safety," American Physical Society March Meeting, Boston, MA, March 1, 2012.

"Lessons from Fukushima for Improving Nuclear Safety," Physics Department Colloquium, University of Central Florida, February 24, 2012.

Testimony on the Blue Ribbon Commission Report before the House Committee on Energy and Commerce, Subcommittee on Environment and the Economy, February 1, 2012.

"UCS Perspective on the Prioritization of NTTF Recommendations," presentation at NRC Commission briefing, October 11, 2011.

"UCS Perspective on the Japan Task Force Report Short-Term Actions," presentation at NRC Commission briefing, September 14, 2011.

Testimony on small modular reactors before the Senate Committee on Appropriations, Energy and Water Subcommittee, July 14, 2011.

Testimony on nuclear power legislation before the Senate Energy and Natural Resources Committee, June 7, 2011.

Testimony on the U.S. government response to Fukushima before the House Energy and Commerce Committee, Subcommittee on Oversight and Investigations, April 6, 2011.

Testimony on nuclear safety and Fukushima before the Senate Committee on Environment and Public Works, March 16, 2011.

"UCS Perspective on Maintaining Enhanced Safety for New Reactors," presentation at NRC Commission briefing, October 14, 2010.

"Limiting Future Proliferation and Security Risks," presentation to the Blue Ribbon Commission on America's Nuclear Future, Reactor and Fuel Cycle Technology Subcommittee, October 12, 2010.

"Opportunities in Reactor and Fuel Cycle Technologies ," presentation to the Blue Ribbon Commission on America's Nuclear Future, Reactor and Fuel Cycle Technology Subcommittee, August 30, 2010.

"Proliferation and Terrorism Risks of the 'Nuclear Renaissance,'" New York State American Physical Society meeting, April 24, 2010.

"Reprocessing in the U.S.: Just Say No," presentation at the NRC Fuel Cycle Information Exchange, June 25, 2009.

"Nuclear Concerns: Safety, Security, Waste and Proliferation," presentation at the Nuclear Nonoperating Owners' Group Conference, Baltimore, MD, April 23, 2009.

"NRC Regulation of the Nuclear Fuel Cycle: Safety and Security Concerns," presentation at the NRC Regulatory Information Conference, March 11, 2009.

"UCS Views on Risk-Informed Regulation," presentation at NRC Commission briefing, February 4, 2009.

"Licensing Challenges for Fuel Cycle Facilities Under the Global Nuclear Energy Partnership," U.S. Nuclear Regulatory Fuel Cycle Information Exchange, Rockville, MD, June 12, 2007.

"The 'Nuclear Renaissance' and the Spread of Nuclear Weapons," American Physical Society Ohio Chapter Meeting, May 7, 2007.

"Recycling Nuclear Waste," American Physical Society Annual April Meeting, Jacksonville, FL, April 15, 2007.

"The Security Imperative of Eliminating Commercial Use of HEU," presentation to the Committee on Medical Isotope Production Without Highly Enriched Uranium, National Academy of Sciences, Washington, DC, February 15, 2007.

"Recycling Nuclear Waste," Peace Studies Seminar, Cornell University, November 29, 2006.

"Nuclear Power and Nuclear Proliferation," Citizens for Global Solutions conference, Washington, DC, November 13, 2006.

"Next-Generation Nuclear Plants: Safety and Security," presented at "Is Nuclear Power a Solution to Global Warming and Rising Energy Prices?," American Enterprise Institute conference, Washington, DC, October 6, 2006.

"Recycling Nuclear Waste: Technical Difficulties and Proliferation Concerns," Physics Department Colloquium, Case Western Reserve University, Cleveland, OH, September 14, 2006.

"The Chernobyl Source Term: Implications for Nuclear Safety," international conference "Chornobyl +20: Remembrance for the Future," Kiev, Ukraine, April 23-25, 2006.
"Public Health Consequences of a Severe Accident or Attack at a Nuclear Plant," Nuclear Policy Research Institute Conference on Nuclear Power and Global Warming, Airlie House, Warrenton, VA, November 7, 2005.

Testimony before the Subcommittee on Clean Air, Climate Change on Nuclear Safety, Committee on Environment and Public Works, United States Senate, May 26, 2005.

"Safeguarding the U.S. Plutonium Disposition Program Against Nuclear Terrorism," Science and Global Security Program seminar, Woodrow Wilson School of Public and International Affairs, Princeton University, December 9, 2004.

"Status of the Security Regime for the U.S. Mixed-Oxide Fuel Program," Managing the Atom Project seminar, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, November 2, 2004.

"U.S. Nonproliferation Policy, Plutonium Disposition and the Threat of Nuclear Terrorism," seminar on "Recycling Plutonium: Risks and Alternatives," sponsored by the Green Group, European Parliament, Brussels, Belgium, January 9, 2003.

"Current Status of the U.S. Plutonium Disposition Program," seminar, Princeton University Program on Science and Global Security, Princeton University, Princeton, NJ, June 12, 2002.

"Controlling Fissile and Radioactive Material," Public Health Summit on Weapons of Mass Destruction, sponsored by Physicians for Social Responsibility and the UCLA School of Public Health, UCLA, Los Angeles, June 2, 2002.

"Assessing the U.S. Government Response to the Nuclear Terrorism Threat After 9/11," presentation to the Joint Atomic Energy Intelligence Committee, McLean, VA, May 9, 2002.

"Upgrading Physical Protection at Nuclear Facilities to Address New Threats," MIT Security Studies Seminar, MIT, Boston, MA, April 18, 2002.

"Perspectives on New Plant Licensing," presentation at the U.S. Nuclear Regulatory Commission Briefing on Readiness for New Plant Applications and Construction, Washington, DC, July 19, 2001.

"Regulatory Challenges for Future Nuclear Plant Licensing: A Public Interest Perspective," U.S. NRC Advisory Committee on Reactor Safeguards (ACRS) Workshop on New Nuclear Plant Licensing, Washington, DC, June 5, 2001.

"The Future of Nuclear Power: A Public Interest Perspective," 2001 Symposium of the Northeast Chapter of Public Utility Commissioners, Mystic, CT, May 21, 2001.

Statement at the U.S. Nuclear Regulatory Commission Briefing on Office of Nuclear Regulatory Research Programs and Performance, May 11, 2001.

"Barriers to Deployment of Micro-Nuclear Technology," presentation at the workshop on "New Energy Technologies: A Policy for Micro-Nuclear Technologies," James A. Baker III Institute for Public Policy, Rice University, Houston, TX, March 19-20, 2001.

"Aging Research and Public Confidence," presentation at the U.S. Nuclear Regulatory Commission 2001 Regulatory Information Conference (RIC), Washington, DC, March 14, 2001.

"NRC Reactor Safeguards Activities," presentation at the U.S. Nuclear Regulatory Commission 2001 Regulatory Information Conference (RIC), Washington, DC, March 14, 2001.

"DOE's Nuclear Material Stabilization Approach: The Failure of Transparency," Embedded Topical Meeting on DOE Spent Nuclear Fuel and Fissile Material Management, American Nuclear Society Annual Meeting, San Diego, CA, June 2000.

"The Status of Reactor Safeguards Initiatives," presentation at the U.S. NRC 2000 Regulatory Information Conference, Washington, DC, March 29, 2000.

"Safety Questions Concerning MOX Fuel Use in Proposed U.S. Reactors," Sixth International Policy Forum on the Management and Disposition of Nuclear Weapons Materials, sponsored by Exchange/Monitor Publications, Washington, DC, June 1999.

"Transparency and Plutonium Disposition," ISIS Workshop on Comprehensive
Controls on Plutonium and Highly Enriched Uranium: Long-Term Problems and Prospects for Solutions, sponsored by the Institute for Science and International Security, Washington, DC, June 1997.

"Ship Transportation of Radioactive Materials," presentation to the Marine Board of the National Research Council, U.S. National Academy of Sciences, Woods Hole, MA, June 20, 1996.

"The Importation and Storage of High-Level Radioactive Wastes at Rokkasho-Mura: Safety Concerns," presentation at the Public Forum on High-Level Nuclear Waste and Reprocessing," Aomori, Japan, April 16, 1996.

"Perspectives on U.S. Options for Disposition of Excess Plutonium," Third International Policy Forum on the Management and Disposition of Nuclear Weapons Materials, sponsored by Exchange/Monitor Publications, Landsdowne, VA, March 21, 1996.

"Addressing Safety Issues in the Sea Transport of Radioactive Materials," presentation to the Special

Consultative Meeting of Entities Involved in the Marine Transport of Nuclear Materials Covered by the INF Code," International Maritime Organization, London, March 4-6, 1996.

"Prospects and Unsolved Issues for Plutonium Immobilization," INESAP/IANUS/UNIDIR Fissile Cutoff Workshop, Palais des Nations, Geneva, June 1995.

"An Intermediate Solution for Plutonium from Dismantled Nuclear Warheads," Annual Meeting of the German Physical Society, Berlin, Germany, March 1995.

"The Sea Transport of High-Level Radioactive Waste: Environmental and Health Concerns," Channel Islands International Conference on Nuclear Waste, St. Helier, Jersey, United Kingdom, January 1995.

Conference Papers

E. Lyman, "Security and Nonproliferation Assessment of Breed-and-Burn Systems," GLOBAL 2015 Conference, Paris, France, September 2015.

E. Lyman, "Material Accounting Issues at the MOX Fuel Fabrication Facility," 2014 IAEA Safeguards Symposium, International Atomic Energy Agency, Vienna, Austria, October 2014.

E. Lyman, "Spent Nuclear Fuel Sabotage: An Unnecessary Risk?" 55th Annual Meeting of the Institute of Nuclear Materials Management, Atlanta GA, July 2014.

E. Lyman, "WIPP and Plutonium Disposition: End of the Spent Fuel Standard?" 54th Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, CA, July 2013.

E. Lyman, "MC&A Issues at the MOX Fuel Fabrication Facility," 53th Annual Meeting of the Institute of Nuclear Materials Management, Orlando, FL, July 2012.

E. Lyman, "A Comprehensive Approach to Protecting Nuclear Facilities and Materials from Terrorist Threats," 2012 Seoul Nuclear Security Symposium, Seoul, Republic of Korea, March 2012.

E. Lyman, "Is Dilution the Solution to the Plutonium Threat?" 52th Annual Meeting of the Institute of Nuclear Materials Management, Palm Desert, CA, July 2011.

E. Lyman, "Resolving a Safeguards Paradox," 2010 IAEA Safeguards Symposium, International Atomic Energy Agency, Vienna, Austria, November 2010.

E. Lyman, "NRC: Taking Spent Fuel Security in the Wrong Direction," 51th Annual Meeting of the Institute of Nuclear Materials Management, Baltimore, MD, July 2010.

E. Lyman, "Severe Accident Consequence Assessment Regulatory Guidance: A Critique," American Nuclear Society Annual Meeting, San Diego, CA, June 2010.

E. Lyman, "Promoting Mediocrity: NRC's Policy for New Facility Security Design," 50th Annual Meeting of the Institute of Nuclear Materials Management, Tucson, AZ, July 2009.

E. Lyman, "Excess Plutonium Disposition: Requiem for a Dream," 49th Annual Meeting of the Institute of Nuclear Materials Management, Nashville, TN, July 2008.

E. Lyman, "Revising the Rules for Material Protection, Control and Accounting," 8th International Conference on Facility Operations – Safeguards Interface, Portland, OR, March 30 – April 4, 2008.

E. Lyman, "Regulatory Challenges Facing the Global Nuclear Energy Partnership," GLOBAL 2007 Conference, Boise, ID, September 2007.

E. Lyman, "Envisioning a World Without Uranium Enrichment," 48th Annual Meeting of the Institute of Nuclear Materials Management, Tucson, AZ, July 2007.

E. Lyman, "The Global Nuclear Energy Partnership: Will it Advance Nonproliferation or Undermine it?" 47th Annual Meeting of the Institute of Nuclear Materials Management, Nashville, TN, July 2006.

E. Lyman, "Can Nuclear Fuel Production in Iran and Elsewhere Be Protected Against Diversion?" paper presented at the Nonproliferation Policy Education Center/King's College-London Conference "After Iran: Safeguarding Peaceful Nuclear Energy," London, October 2-3, 2005.

E. Lyman, "The Erosion of Physical Protection Standards Under the MOX Fuel Program," 46th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, AZ, July 2005.

E. Lyman, "Extending the Foreign Spent Fuel Acceptance Program: Policy and Implementation Issues," 26th International Meeting on Reduced Enrichment for Research and Test Reactors, IAEA, Vienna, Austria, November 2004.

E. Lyman, "Using Bilateral Mechanisms to Strengthen Physical Protection Worldwide," 45th Annual Meeting of the Institute of Nuclear Materials Management, Orlando, FL, July 2004.

E. Lyman, "The Congressional Attack on RERTR," 25th International Meeting on Reduced Enrichment for Research and Test Reactors, RERTR-2003, Chicago, IL, October 2003.

E. Lyman, "Nuclear Plant Protection and the Homeland Security Mandate," 44th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, AZ, July 2003.

E. Lyman and A. Kuperman, "A Reevaluation of Physical Protection Standards for Irradiated HEU Fuel," 24th International Meeting on Reduced Enrichment for Research and Test Reactors, RERTR-2002, Bariloche, Argentina, November 2002.

E. Lyman, "Material Protection, Control and Accounting at the U.S. MOX Fuel Fabrication Plant: Merely an Afterthought?" 43rd Annual Meeting of the Institute of Nuclear Materials Management (INMM), Orlando, FL, June 2002.

E. Lyman, "Terrorism Threat and Nuclear Power: Recent Developments and Lessons to be Learned," Symposium on Rethinking Nuclear Energy and Democracy after 9/11, sponsored by PSR/IPPNW Switzerland, Basel, Switzerland, April 2002.

E. Lyman, remarks for Expert Panel on Advanced Reactors, Nuclear Safety Research Conference, U.S. Nuclear Regulatory Commission, Washington, DC, October 2001.

E. Lyman, "The Future of Immobilization Under the U.S.-Russian Plutonium Disposition Agreement," 42nd Annual Meeting of the Institute of Nuclear Materials Management (INMM), Indian Wells, CA, July 18, 2001.

E. Lyman, comments in *the Report of the Expert Panel on the Role and Direction of Nuclear Regulatory Research*, U.S. Nuclear Regulatory Commission, May 2001.

E. Lyman, "Can the Proliferation Risks of Nuclear Power be Made Acceptable?" Nuclear Control Institute 20th Anniversary Conference, Washington, DC, April 9, 2001.

E. Lyman and P. Leventhal, "Radiological Sabotage at Nuclear Power Plants: A Moving Target Set," 41st Annual Meeting of the INMM, New Orleans, LA, July 2000.

E. Lyman, "Comments on the Storage Criteria for the Storage and Disposal of Immobilized Plutonium," Proceedings of the Institute for Science and International Security Conference on "Civil Separated Plutonium Stocks --- Planning for the Future," March 14-15, 2000, Washington, DC, Isis Press, 135.

E. Lyman, "The Sea Shipment of Radioactive Materials: Safety and Environmental Concerns," Conference on Ultrahazardous Radioactive Cargo by Sea: Implications and Responses, sponsored by the Maritime Institute of Malaysia, Kuala Lumpur, Malaysia, October 1999.

E. Lyman, "A Critique of Physical Protection Standards for Irradiated Materials," 40th Annual Meeting of the INMM, Phoenix, AZ, July 1999.

E. Lyman, "DOE Reprocessing Policy and the Irreversibility of Plutonium Disposition," Proceedings of the 3rd Topical Meeting on DOE Spent Nuclear Fuel and Fissile Materials Management, American Nuclear Society, Charleston, SC, September 8-11, 1998, 149.

E. Lyman, "Japan's Plutonium Fuel Production Facility (PFPF): A Case Study of the Challenges of Nuclear Materials Management," 39th Annual Meeting of the INMM, Naples, FL, July 1998.

E. Lyman, "Safety Aspects of Unirradiated MOX Fuel Transport," Annex 2b of the *Comprehensive Social Impact Assessment of MOX Use in Light Water Reactors*, Citizens' Nuclear Information Center, Tokyo, November 1997.

E. Lyman, "Unresolved Safety Issues in the Storage and Transport of Vitrified High-Level Nuclear Waste," 38th Annual Meeting of the INMM, Phoenix, AZ, July 1997.

E. Lyman, "A Perspective on the Proliferation Risks of Plutonium Mines," proceedings of the Plutonium Stabilization and Immobilization Workshop, U.S. Department of Energy, Washington, DC, December 12-14, 1995, CONF-951259, p, 445.

E. Lyman, "Assessing the Proliferation and Environmental Risks of Partitioning-Transmutation," Fifth International Summer Symposium on Science and World Affairs, Cambridge, MA, USA, July 1993.

Letters to the Editor and Op-Eds

E. Lyman, "Nuclear Cybersecurity: Why We Should Worry," New York Times, January 26, 2016.

E. Lyman and F. von Hippel, "Direct Disposal is a Better Solution for South Carolina's Plutonium Problem" (op-ed), Augusta Chronicle, October 24, 2015.

E. Lyman, "The Value of a Life," New York Times, February 23, 2011.

E. Lyman, "The Downside of Nuclear Energy," Washington Post, April 21, 2006.

E. Lyman, "Reprocessing Nuclear Waste: Forget It," Topeka Capital-Journal, December 24, 2005.

E. Lyman, "The Wrong Way to Get Cheap Electricity, Chicago Sun-Times, December 16, 2005.

E. Lyman, "Uranium on Campus," New York Times, August 23, 2004

L. Gronlund and E. Lyman, "Halting the Spread of Nuclear Arms," New York Times, December 28, 2003.

E. Lyman, "Troubles at Indian Point," New York Times, January 25, 2003.

E. Lyman and P. Leventhal, "Nonessential Nukes" (op-ed), Washington Post, November 26, 2002.

P. Leventhal and E. Lyman, "Shipping Plutonium," New York Times, July 12, 2002.

E. Lyman, "Indian Point Reactor," New York Times, January 27, 2002.

E. Lyman, "Spent Nuclear Fuel," New York Times, June 3, 2001.

E. Lyman and P. Leventhal, "Better Plutonium Plan," New York Times, February 5, 1998.

E. Lyman, "A Safer Plutonium Plan," Washington Post, August 24, 1997.

P. Leventhal and E. Lyman, "Who Says Iraq Isn't Making a Bomb?" International Herald Tribune, November 2, 1995.

H. Feiveson and E. Lyman, "No Solution to the Plutonium Problem," Washington Post, July 29, 1994.

E. Lyman, "Getting Rid of Weapon Plutonium," *Bulletin of the Atomic Scientists,* July/August 1994.

Attachment 4

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 52-047-ESP
Tennessee Valley Authority	)	
	)	
(Clinch River Nuclear Site)	)	
	)	

DECLARATION OF DR. M.V. RAMANA IN SUPPORT OF INTERVENORS' NEW CONTENTION 4 (IMPERMISSIBLE DISCUSSION OF ENERGY ALTERNATIVES AND NEED FOR PROPOSED SMR)

Under penalty of perjury, M.V. Ramana declares as follows:

1. My name is M.V. Ramana. I am a Professor and the Simons Chair in Disarmament, Global and Human Security at the Liu Institute for Global Issues, University of British Columbia, Vancouver, Canada.

2. I am a qualified expert on matters relating to nuclear energy policy and economics. I have a Ph.D. in Theoretical Physics from Boston University and a M.Sc. in Physics from the Indian Institute of Technology, Kanpur, India. I have written many academic papers and articles on a wide range of topics relating to nuclear energy in various journals and magazines, including *Scientific American*, *Science and Global Security*, *Energy Policy*, *Nuclear Technology*, *Journal of Risk Research*, *Environmental Impact Assessment Review*, *Energy Research and Social Science*, and *International Journal of Global Energy Issues*. I have also been a member of many professional organizations relevant to my area of expertise, including the International Panel on Fissile Materials and the Science and Security Board of the Bulletin of the Atomic Scientists. A copy of my curriculum vitae is attached.

3. I am familiar with the licensing-related filings and correspondence that have been submitted by Tennessee Valley Authority ("TVA") in support of its application to the U.S. Nuclear Regulatory Commission ("NRC") for an Early Site Permit for a Small Modular Reactor ("SMR") on the Clinch River Nuclear Site, particularly TVA's Environmental Report. I am also familiar with the Draft Environmental Impact Statement prepared by the NRC for the proposed ESP. NUREG-2226, Draft Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Nuclear Site (April 2018) ("Draft EIS"). And I am familiar with applicable NRC regulations, policies, and guidance documents.

4. I am familiar with the history of development of nuclear technology in the United States, including the development and operation of light water reactors and the development of SMR designs. I am also familiar with the characteristics and costs of a range of technologies available or currently being developed for electricity generation, including coal and gas based power plants; renewable energy sources such as solar and wind; and nuclear energy. I have researched and written papers on various technical and policy issues related to SMRs, including their technical characteristics, uranium fuel requirements and spent fuel generation, challenges with their licensing, conflicts between design priorities, and demand for them in developing countries.

4. I assisted Intervenors with the preparation of their new Contention 4, which asserts that the Draft EIS violates NEPA and NRC implementing regulations 10 C.F.R. §§ 51.75(b), 51.20(b), and 52.21, by impermissibly including an extensive discussion of the economic and technical benefits of the proposed SMR, including need for power and alternative energy sources. The factual assertions in the contention are true and correct to the best of my knowledge, and the opinions expressed therein are based on my best professional judgment.

M.V. Ramana, Ph.D.

May 18, 2018

CURRICULUM VITAE

M. V. Ramana
email: m.v.ramana@ubc.ca
Phone: 604 822 8838

Liu Institute for Global Issues
School of Public Policy and Global Affairs
University of British Columbia

EMPLOYMENT

Simons Chair in Disarmament, Global and Human Security, Liu Institute for Global Issues, School of Public Policy and Global Affairs, University of British Columbia	January 2017 onwards
Professional Specialist, Program in Science and Global Security, Princeton University Researching issues related to nuclear power, nuclear proliferation and climate change	July 2012 – December 2016
Associate Research Scholar, Program in Science and Global Security, Princeton University Researching issues related to nuclear power, nuclear proliferation and climate change	November 2009 – June 2012
Lecturer, Woodrow Wilson School of Public and International Affairs Designed and taught courses related to energy, environment and development, and nuclear power for Masters students and Freshmen	March 2010 – May 2012, Fall 2013, Fall 2014, Spring 2016
Visiting Research Scholar, Program in Science, Technology, and Environmental Policy, Woodrow Wilson School of Public and International Affairs, Princeton University Researching issues related to nuclear power and climate change	May 2009 – November 2009
Senior Fellow, Centre for Interdisciplinary Studies in Environment and Development, Bangalore	April 2007 – April 2009
Fellow, Centre for Interdisciplinary Studies in Environment and Development, Bangalore	April 2004 – April 2007

Researched economic and environmental aspects of India's nuclear energy program

Research Staff, Program on Science and Global Security, Princeton University	September 2001 – March 2004

Researched global nuclear disarmament and India's nuclear weapons and energy programs

Lecturer, Woodrow Wilson School of Public and International Affairs, Princeton University	September 2001 – February 2002

Lectured and conducted precepts for a course on Methods in Science, Technology, and Environmental Policy

Lecturer, Yale Center for International and Area Studies, Yale University	August 2001 – December 2001

Designed and taught course on Science, Technology, and Development in India

Research Associate, Center for Energy and Environmental Studies, Princeton University — September 1998 – August 2001
Conducted research on technical aspects of nuclear disarmament and India's nuclear weapons and energy programs; influence of scientists on nuclear policy

Lecturer, Woodrow Wilson School of Public and International Affairs, Princeton University — February 1999 – July 1999
Gave lectures and conducted precepts for a course on Science, Technology, and Public Policy

Post-doctoral Fellow, Security Studies Program, Massachusetts Institute of Technology — August 1996 – August 1998
Conducted research on technical aspects of nuclear weapons and disarmament, Indian ballistic missiles, and India's nuclear policy

Post-doctoral Fellow, Physics Department, University of Toronto — September 1994 - July 1996
Conducted theoretical research on tests of particle physics models at accelerator experiments

Research Fellow, Physics Department, Boston University — June 1989 – August 1994
Conducted research on phenomenological aspects of electroweak symmetry breaking

EDUCATION

Boston University, Ph.D., Physics, September 1994 — Thesis Advisor: Kenneth D. Lane
Thesis Title: "Phenomenological Aspects of Electroweak Symmetry Breaking"

Indian Institute of Technology, Kanpur, M.Sc. Physics, May 1988

HONORS, AWARDS, PROFESSIONAL SERVICE

Member, Team of Editors, *Journal of Peace and Nuclear Disarmament*, since 2017

Member, Editorial Board, *Science and Global Security*, since 2017

Distinguished Lecturer, Sigma Xi Society, 2017-18

Leo Szilard Award, American Physical Society, 2014

Member, International Panel on Fissile Materials, since 2005

Member, Science and Security Board of the Bulletin of Atomic Scientists, 2008-2014

Member, Editorial Board, *Energy Research and Social Science*, since 2015

Robert Jay Lifton Fellowship, John Jay College of Criminal Justice, City University of New York, 2005

Guggenheim Fellowship, 2003

Member, Selection Committee, Global Security and Cooperation Program, Social Sciences Research Council, 2000-01

MacArthur Foundation Research and Writing Grant, 1999

SSRC-MacArthur Fellowship for International Research on Peace and Security, 1999

SSRC-MacArthur Post-doctoral Fellowship on Peace and Security in a Changing World, 1996

National Talent Search Scholarship, 1981 -1988

Reviewed papers for several journals including *Bulletin of the Atomic Scientists, Climate Policy*, *Energy Policy*, *Journal of Environment and Development*, *Environmental Politics, Journal of Risk Research, Energy Strategy Reviews, Economic and Political Weekly*, and *Energy for Sustainable Development.*

PUBLICATIONS

Refereed Publications

Journal Articles

M. V. Ramana, "Technical and social problems of nuclear waste," *WIREs Energy and Environment* (2018) doi.org/ 10.1002/wene.289.

Kumar Sundaram and M. V. Ramana, "India and the policy of no first use of nuclear weapons," *Journal for Peace and Nuclear Disarmament* (2018) doi.org/10.1080/25751654.2018.1438737.

Matthias Englert, Friederike Frieß, and M. V. Ramana, "Accident Scenarios Involving Pebble Bed High Temperature Reactors," *Science and Global Security*, **25**, no. 1 (2017), 42-55.

M. V. Ramana, A. H. Nayyar, and Michael Schoeppner, "Nuclear High-level Waste Tank Explosions: Potential Causes and Impacts of a Hypothetical Accident at India's Kalpakkam Reprocessing Plant," *Science and Global Security*, **24**, no. 3 (2016), 174-203.

M. V. Ramana and Priscilla Agyapong, "Thinking Big? Ghana, Small Reactors, and Nuclear Power," *Energy Research and Social Science*, **21** (2016), 101-113.

M. V. Ramana and Ali Ahmad, "Wishful Thinking and Real Problems: Small Modular Reactors, Planning Constraints, and Nuclear Power in Jordan," *Energy Policy*, **93** (2016), 236–245.

Amy King and M. V. Ramana, "The China Syndrome? Nuclear Power Growth and Safety After Fukushima," *Asian Perspective*, **39** (2015), 607-636.

M. V. Ramana and Ashwin K. Seshadri, "Negligence, Capture, and Dependence: Safety Regulation of the Design of India's Prototype Fast Breeder Reactor," *Journal of Risk Research*, **18**, no. 8 (2015), 1030-1050.

Benjamin Sovacool and M. V. Ramana, "Back to the Future: Small Modular Reactors, Nuclear Fantasies, and Symbolic Convergence," *Science, Technology, and Human Values*, **40**, no. 1 (2015), 96-125.

M. V. Ramana and Zia Mian, "One Size Doesn't Fit All: Social Priorities and Technical Conflicts for Small Modular Reactors," *Energy Research and Social Science* **2** (May 2014), 115-124.

Ali Ahmad and M. V. Ramana, "Too Costly to Matter: Economics of Nuclear Power for Saudi Arabia," *Energy* **69** (May 2014), 682-694.

M. V. Ramana, Laura Berzak Hopkins, and Alexander Glaser, "Licensing Small Modular Reactors," *Energy* **61**, (November 2013), 555-564.

M. V. Ramana and Ashwin Kumar, "'One in Infinity': Learning from Accidents and Lessons for Nuclear Safety in India," *Journal of Risk Research* (2013), 23-42.

Alexander Glaser, Laura Berzak Hopkins, and M. V. Ramana, "Resource Requirements and Proliferation Risks Associated with Small Modular Reactors," *Nuclear Technology* **184**, (October 2013), 121-129.

M. V. Ramana, "Shifting Strategies and Precarious Progress: Nuclear Waste Management in Canada," *Energy Policy* **61**, (October 2013), 196-206.

M. V. Ramana and Eri Saikawa, "Choosing a Standard Reactor: International Competition and Domestic Politics in Chinese Nuclear Policy," *Energy* **36** (2011), 6779-6789.

J. Y. Suchitra and M. V. Ramana, "The Costs of Power: Plutonium and the Economics of India's Prototype Fast Breeder Reactor," *International Journal of Global Energy Issues* **35**, no. 1 (2011), 1-23.

M. V. Ramana and Divya Badami Rao, "The Environmental Impact Assessment Process for Nuclear Facilities: An Examination of the Indian Experience," *Environmental Impact Assessment Review* **30**, no. 4 (2010), 268-271.

M. V. Ramana and Ashwin Kumar, "Least Cost Principles and Electricity Planning for Karnataka," *Energy for Sustainable Development* **13**, no. 4 (2009), 225–234.

M. V. Ramana and J. Y. Suchitra, "Slow and Stunted: Plutonium Accounting and the Growth of Fast Breeder Reactors in India," *Energy Policy* **37**, no. 12 (2009), 5028-5036.

M. V. Ramana "India and Fast Breeder Reactors," *Science and Global Security* **17** (2009), 54-67.

M. V. Ramana and Ashwin Kumar, "Compromising Safety: Design Choices and Severe Accident Possibilities in India's Prototype Fast Breeder Reactor," *Science and Global Security* **16** (2008), 87-114.

Alexander Glaser and M. V. Ramana, "Weapon-Grade Plutonium Production Potential in the Indian Prototype Fast Breeder Reactor," *Science and Global Security* **15** (2007), 85-105.

M. V. Ramana and J. Y. Suchitra, "Costing Plutonium: Economics of Reprocessing in India," *International Journal of Global Energy Issues* **27**, no. 4 (2007), 454-471.

Zia Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana, "Fissile Materials in South Asia and the Implications of the U.S.-India Nuclear Deal," with *Science and Global Security* **14** (2006), 117-143.

M. V. Ramana, Antonette D'Sa, and Amulya Reddy, "Nuclear Energy Economics in India," *Energy for Sustainable Development* **IX**, no. 2 (June 2005), 35-48.

M. V. Ramana, "An Estimate of India's Uranium Enrichment Capacity," *Science and Global Security* **12** (2004), 115-124.

Zia Mian, R. Rajaraman, and M. V. Ramana, "Early Warning in South Asia: Constraints and Implications," *Science and Global Security* **11** (2003), 109–150.

M. V. Ramana, Dennis Thomas, and Susy Varughese, "Estimating Nuclear Waste Production in India," *Current Science* **81**, no. 11 (December 10, 2001), 1458-1462.

Zia Mian, M. V. Ramana, and R. Rajaraman, "Plutonium Dispersion and Health Hazards from Nuclear Weapons Accidents," *Current Science* **80**, no. 10 (May 25, 2001), 1275-1284.

Z. Mian, A. H. Nayyar, and M. V. Ramana, "Bringing Prithvi Down to Earth: The Capabilities and Potential Effectiveness of India's Prithvi Missile," *Science and Global Security* **7,** no. 3 (1998), 333-360.

M. V. Ramana, "Gauge Boson Scattering in a Hidden Symmetry Breaking Sector at *e+e-* Colliders," *Modern Physics Letters* **A11** (1996), 247-255.

M. V. Ramana "Glueballs in Strongly Interacting Theories at the Electroweak Scale," *Physics Letters* **B368** (1996), 215-220.

B. Holdom and M. V. Ramana, "New Flavor Physics in *b* Decays," *Physics Letters* **B365** (1996), 309-311.

B. Holdom and M. V. Ramana, "A New Physics Source of Hard Gluons in Top Quark Production," *Physics Letters* **B353** (1995), 295-300.

R. S. Chivukula, M. Golden, D. Kominis, and M. V. Ramana, "The Phenomenology of a Hidden Symmetry Breaking Sector," *Physics Letters* **B293** (1992), 400-404.

R. S. Chivukula, M. Golden, and M. V. Ramana, "Colored Pseudo-Goldstone Bosons and Gauge Boson Pairs," *Physical Review*. *Letters* **68** (1992), 2883-2886.

K. Lane and M. V. Ramana, "Walking Technicolor Signatures at Hadron Colliders," *Physical Review* **D44** (1991), 2678-2700.

Conference Proceedings

Wei Peng, Fabian Wagner, Denise L Mauzerall, M.V. Ramana, Haibo Zhai, Mitchell Small, Xin Zhang, and Carole Dalin, "Competing Air Quality and Water Conservation Cobenefits from Power Sector Decarbonization," in *American Geophysical Union Fall Meeting*, December 12-16, 2016, San Francisco, USA.

M. V. Ramana, Alexander Glaser, and Laura Berzak Hopkins,"Small Modular Reactors: Uranium Resource Requirements, Waste Generation and Proliferation Risk Assessment," in *21st International Conference on Nuclear Engineering*, July 29 to August 2, 2013, Chengdu, China, 1-7.

M. V. Ramana, "Constraints on India's Fast Breeder Program," in *51st Annual Meeting of the Institute of Nuclear Materials Management,* July 13, 2010, Baltimore, USA, 1-9.

M. V. Ramana and J. Y. Suchitra, "Economic and Environmental Costs of Nuclear Power," in *Ninth Biennial Conference of the International Society of Ecological Economics*, December 15-18, 2006, New Delhi, India, 1-21.

Non-Refereed Publications

Journal Articles

M. V. Ramana and Zia Mian, "The Courage to Challenge the Nuclear World Order," *Economic and Political Weekly*, **52**, no. 48 (2 December 2017), 22-25.

M. V. Ramana, "Small Modular Reactors for Nuclear Power: Hope or Mirage?," *Energy Studies Institute Bulletin*, **10**, no. 6 (December 2017), 10-11.

M. V. Ramana and Suvrat Raju, "Old Plans, Ongoing Handouts, New Spin: Deciphering the Nuclear Construction Announcement," *Economic and Political Weekly*, **52**, no. 24 (17 June 2017). http://www.epw.in/journal/2017/24/web-exclusives/old-plans-ongoing-handouts-new-spin.html.

M. V. Ramana, "An Enduring Problem: Radioactive Waste from Nuclear Energy," *Proceedings of the IEEE*, **105**, no. 3, (March 2017), 415-418.

M. V. Ramana and Zia Mian, "Small Modular Reactors and the Challenges of Nuclear Power," *Physics & Society*, **45**, no. 4 (January 2017), 5-9.

M. V. Ramana, "The Frontiers of Energy: A Gradual Decline?," *Nature Energy*, **1**, no. 1 (2016), 7-8.

M. V. Ramana and Zia Mian, "Scrambling to build a Nuclear Middle East," *Bulletin of the Atomic Scientists*, **72**, no. 1 (2016), 39-43.

M. V. Ramana, "The Checkered Operational History of High Temperature Gas Cooled Reactors," *Bulletin of the Atomic Scientists*, **72**, no. 3 (2016), 171-179.

M. V. Ramana, "A Principled and Knowledgeable Critic: Praful Bidwai on Nuclear Weapons and Energy, *Economic and Political Weekly*, **L**, no. 32 (August 2015), 23-26.

M. V. Ramana, "Atomic State: Big Science in Twentieth-Century India," Book Review, *Technology and Culture* **55** (July 2014), 762-763

S Rajendran Pillai and M. V. Ramana, "Breeder reactors: A Possible Connection Between Metal Corrosion and a History of Sodium Leaks," *Bulletin of the Atomic Scientists* **70**, no. 3 (May/June 2014), 49-55.

Zia Mian and M. V. Ramana, "Asian War Machines," *Critical Asian Studies* **46**, no. 2 (June 2014), 345-360.

Ashwin Kumar and M. V. Ramana, "Nuclear Safety in India: Theoretical Perspectives and Empirical Evidence," *OUCIP Journal of International Studies* **1**, no. 1 (July—December 2013), 49-72.

M. V. Ramana, "Why India's electricity is Likely to Remain in Short Supply: The Economics of Nuclear Power," *Bulletin of the Atomic Scientists* **69**, no. 6 (November/December 2013), 67–78.

Benjamin K. Sovacool, Patrick Parenteau, M. V. Ramana, Scott V. Valentine, Mark Z. Jacobson, Mark A. Delucchi, and Mark Diesendorf, "Comment on "Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power'," *Environmental Science and Technology* **47**, (May 2013), 6715-6717.

Suvrat Raju and M. V. Ramana, "Cost of Electricity from the Jaitapur Nuclear Power Plant," *Economic and Political Weekly* **XLVIII**, no. 26 & 27 (2013), 51-60.

M. V. Ramana, "Nuclear policy responses to Fukushima: Exit, Voice, and Loyalty," *Bulletin of the Atomic Scientists* **69**, no. 2 (March/April 2013), 66-76.

M. V. Ramana, "Flunking Atomic Audits," *Economic and Political Weekly* **XLVII**, no. 39 (2012), 10–13.

Ashwin Kumar and M. V. Ramana, "The Limits of Safety Analysis: Severe Nuclear Accident Possibilities at the PFBR," *Economic and Political Weekly* **XLVI**, no. 43 (2011), 44-49.

M. V. Ramana, "Nuclear Power and the Public," *Bulletin of the Atomic Scientists* **67**, no. 4 (July/August 2011), 43 -51.

Zia Mian and M. V. Ramana, "The Enduring Power of Mass Production, Mass Consumption, and Mass Destruction," *Development* **54**, no. 2 (2011), 194-196.

Thomas Cochran, Harold Feiveson, Zia Mian, M. V. Ramana, Mycle Schneider, and Frank von Hippel, "It's Time to Give Up on Breeder Reactors," *Bulletin of the Atomic Scientists* **66**, no. 3, (May/June 2010), 50-56.

Suvrat Raju and M. V. Ramana, "The Other Side of Nuclear Liability," *Economic and Political Weekly*, **XLV**, no. 16, (April 17, 2010), 48-54.

M. V. Ramana and Ashwin Kumar, "Safety First? Kaiga and Other Nuclear Stories," *Economic and Political Weekly* **XLV**, no. 7 (2010), 47-54.

M. V. Ramana, "Nuclear Power: Economic, Safety, Health, and Environmental Issues of Near-Term Technologies," *Annual Review of Environment and Resources* **34** (2009), 127-52.

Divya Badami Rao and M. V. Ramana, "Violating Letter and Spirit: Environmental Clearances for Koodankulam Reactors," *Economic and Political Weekly* **XLIII**, no. 51 (December 20, 2008), 14-18.

Zia Mian and M. V. Ramana, "Going MAD: Ten Years of the Bomb in South Asia,"*Economic and Political Weekly* **XLIII**, no. 26 and 27 (June 28, 2008), 201-208.

U. A. Shimray and M. V. Ramana, "Uranium Mining in Meghalaya: Simmering Problem," *Economic and Political Weekly* **XLII**, no. 52 (December 29, 2007), 13-17.

M. V. Ramana, "Heavy Subsidies in Heavy Water: Economics of Nuclear Power in India," *Economic and Political Weekly* **XLII**, no. 34 (August 25, 2007), 3483-3490.

M. V. Ramana, "Economics of Nuclear Power: Subsidies and Competitiveness," *Economic and Political Weekly* **XLII**, no. 2 (January 13, 2007), 169-171.

J. Y. Suchitra and M. V. Ramana, "High Costs, Questionable Benefits of Reprocessing," *Economic and Political Weekly* **XLI**, no. 47 (November 25, 2006), 4848-4851.

M. V. Ramana, "Twenty Years after Chernobyl: Debates and Lessons," *Economic and Political Weekly* **XLI**, no. 18 (May 6, 2006), 1743-1747.

J. Y. Suchitra and M. V. Ramana, "Nuclear Power: No Route to Energy Security," *Energy Security Insights* **I**, no. 1 (March 2006), 13-16.

Zia Mian and M. V. Ramana, "Wrong Ends, Means, and Needs: Behind the U.S. Nuclear Deal with India," *Arms Control Today* (January/February 2006), 11-17.

M. V. Ramana, "Tall Claim, Little Evidence," *Economic and Political Weekly* **XL**, no. 50 (December 10, 2005), 5237-5239.

M. V. Ramana, "Nuclear Power: Expensive and Unsafe," *Electrical India* **45**, no. 11 (November 2005), 1-11.

Zia Mian and M. V. Ramana, "Feeding the Nuclear Fire," *Economic and Political Weekly* **XL**, no. 35 (August 27, 2005), 3808-3812.

M. V. Ramana, Antonette D'Sa and Amulya Reddy, "Economics of Nuclear Power from Heavy Water Reactors," *Economic and Political Weekly* **XL**, no. 17 (April 23, 2005), 1763-1773.

M. V. Ramana, "India's Uranium Enrichment Program," *International Network of Engineers and Scientists Against Proliferation Bulletin* **24** (December 2004), 71-74.

M. V. Ramana, "Scientists, Nuclear Weapons, and the Peace Movement," *Economic and Political Weekly* **XXXIX**, no. 46-47 (November 20, 2004), 5013-5016.

Zia Mian, A. H. Nayyar, and M. V. Ramana, "Making Weapons, Talking Peace: Resolving Dilemma of Nuclear Negotiations," *Economic and Political Weekly* **XXXIX**, no. 29 (July 17, 2004), 3221-3224.

M. V. Ramana, R. Rajaraman and Zia Mian, "Nuclear Early Warning in South Asia: Problems and Issues," *Economic and Political Weekly* **XXXIX**, no. 3 (January 17, 2004), 279-284.

M. V. Ramana, "Scientists, Nuclear Weapons and Peace in India," *International Network of Engineers and Scientists Against Proliferation Bulletin* **22** (December 2003), 25-27.

M. V. Ramana, "A Stepping Stone to a Fully Nuclear Future," *Science and Global Security* **11** (2003), 81-83.

M. V. Ramana, "Risks of a LOW Doctrine," *Economic and Political Weekly* **XXXVIII**, no. 9 (March 1, 2003), 860-864.

R. Rajaraman, M. V. Ramana, and Zia Mian, "Possession and Deployment of Nuclear Weapons in South Asia: An Assessment of Some Risks," *Economic and Political Weekly* **XXXVII**, no. 25 (June 22, 2002), 2459-65.

M. V. Ramana and A. H. Nayyar, "India, Pakistan and the Bomb" *Scientific American* (December 2001), 73-83.

M. V. Ramana, "South Asian Mode of Weaponisation," *Economic and Political Weekly* **XXXV**, no. 11 (March 11, 2000), 896-897.

M. V. Ramana, "Reinventing the Arms Race," *FORUM for Applied Research and Public Policy* **14**, no. 2 (Summer 1999), 1-6.

Zia Mian and M. V. Ramana, "Disarmament Judo: Using the NPT to make the Nuclear-Weapon States Negotiate the Abolition of Nuclear Weapons," with Zia Mian, *Disarmament Diplomacy* **36** (April 1999), 1-4.

Zia Mian and M. V. Ramana, "Beyond Lahore: From Transparency to Arms Control," *Economic and Political Weekly* **XXXIV**, no. 16-17 (17 April 1999), 938-942.

M. V. Ramana, "India's Nuclear Program: From 1946 to 1998," *International Network of Engineers and Scientists Against Proliferation Bulletin* **16** (November 1998), 8-9.

Zia Mian and M. V. Ramana, "Stepping Away from the Nuclear Abyss: Some Proposals," *International Network of Engineers and Scientists Against Proliferation Bulletin* **16** (November 1998), 12-14.

M. V. Ramana, "Effects of a Nuclear Blast over Bombay," *Medicine and Global Survival* **5,** no. 2 (October 1998), 74-77.

M. V. Ramana, "Do Nuclear Weapons provide Security?" *Seminar* **468** (August 1998), 50-54.

M. V. Ramana, "The Hawks take Flight: India and the Fissile Material Cutoff," *International Network of Engineers and Scientists Against Proliferation Bulletin* **13** (July 1997), 10-12.

Reports and Chapters in Reports

Elena Krieger, Arjun Makhijani, Boris Lukanov, and M. V. Ramana, *A Clean Energy Pathway for New Jersey*, Prepared for New Jersey Conservation Foundation as part of ReThink Energy NJ by the Institute for Energy and Environmental Research and PSE Healthy Energy, September 2017

M. V. Ramana, "Bangladesh," "Canada," "China," "India," "Iran," "Jordan," "Pakistan," and "Small Modular Reactors," in Mycle Schneider and Antony Froggatt, *The World Nuclear Industry Status Report 2017*, Mycle Schneider Consulting, Paris (September 2017), 108-110, 114-117, 151-160, 196-206.

Bernadette K. Cogswell, Nataliawati Siahaan, Friga Siera R, M. V. Ramana, and Richard Tanter, *Nuclear Power and Small Modular Reactors in Indonesia: Potential and Challenges*, Indonesian Institute for Energy Economics and Nautilus Institute for Security and Sustainability, April 2017

Ray Acheson and M. V. Ramana, "India," in Ray Acheson, ed., *Assuring Destruction Forever: 2017 Edition*, Reaching Critical Will, New York (2017), 10-11.

M. V. Ramana, "Bangladesh," "China," "Jordan," "India," "Pakistan," and "United States," in Mycle Schneider and Antony Froggatt, *The World Nuclear Industry Status Report 2016*, Mycle Schneider Consulting, Paris (July 2016), 43-44, 50-53, 125-148, 162-163.

M. V. Ramana and Frank von Hippel, eds., *Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World*, International Panel on Fissile Materials, Princeton (July 2015), 2-178.
Contribution: Report Design: 30%; Writing: 50%; Editing: 50%; Production: 80%

M. V. Ramana, "India" in M. V. Ramana and Frank von Hippel, eds., *Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World*, International Panel on Fissile Materials, Princeton (July 2015), 52-61.

Alexander Glaser, M. V. Ramana, Ali Ahmad, and Robert Socolow, "Small Modular Reactors: A Window on Nuclear Energy," An Energy Technology Distillate from the Andlinger Center for Energy and the Environment at Princeton University (June 2015), 3-27.

M. V. Ramana, "Advanced Nuclear Reactors—The Story of the SMR," in Mycle Schneider and Antony Froggatt, *The World Nuclear Industry Status Report 2015*, Mycle Schneider Consulting, Paris (July 2015), 68-77.

M. V. Ramana, "India," in Ray Acheson, ed., *Assuring Destruction Forever: 2015 Edition*, Reaching Critical Will, New York (2015), 38-43.

M. V. Ramana, "India," in Ray Acheson, ed., *Still Assuring Destruction Forever*, Reaching Critical Will, New York (2013), 10-11.

M. V. Ramana, "Modernizing India's Nuclear Arsenal," in Ray Acheson, ed., *Assuring Destruction Forever: Nuclear Weapon Modernization Around the World*, Reaching Critical Will, New York (2012), 34-43.

Harold Feiveson, Zia Mian, M. V. Ramana, and Frank von Hippel, eds., *Spent Fuel from Nuclear Power Reactors: Experiences and Lessons from Around the World*, International Panel on Fissile Materials, Princeton (2011), 2-182.

M. V. Ramana, "Canada" in Harold Feiveson, Zia Mian, M. V. Ramana, and Frank von Hippel, eds., *Spent Fuel from Nuclear Power Reactors: Experiences and Lessons from Around the World*, International Panel on Fissile Materials, Princeton (2011), 20-29.

Harold Feiveson, M. V. Ramana, and Frank von Hippel, "Multinational Repositories," in Harold Feiveson, Zia Mian, M. V. Ramana, and Frank von Hippel, eds., *Spent Fuel from Nuclear Power Reactors: Experiences and Lessons from Around the World*, International Panel on Fissile Materials, Princeton (2011), 114-121.

M. V. Ramana, "No Escape from Accidents," in Ray Acheson, ed., *Costs, Risks, and Myths of Nuclear Power: NGO World-Wide Study on the Implications of the Catastrophe at the Fukushima Dai-Ichi Nuclear Power Station*, Reaching Critical Will, New York (2011), 26-29.

Andrew Lichterman and M. V. Ramana, "The US-India Nuclear Deal: Violating Norms, Terminating Futures," in Ray Acheson, ed., *Beyond Arms Control: Challenges and Choices for Nuclear Disarmament* (New York: Reaching Critical Will, 2011), 62-70.

M. V. Ramana, "India," in *Global Fissile Material Report 2010: Balancing the Books: Production and Stocks*, International Panel on Fissile Materials, Princeton (2010), 117-125.

M. V. Ramana, "India," in Frank von Hippel, ed., *The Uncertain Future of Nuclear Energy*, International Panel on Fissile Materials, Princeton (2010), 30-32.

M. V. Ramana, "Public Acceptance," in Frank von Hippel, ed., *The Uncertain Future of Nuclear Energy*, International Panel on Fissile Materials, Princeton (2010), 79-82.

M. V. Ramana, "Indian Nuclear Industry: Status and Prospects," *Nuclear Energy Futures Papers*, The Centre for International Governance Innovation, Waterloo, Canada (December 2009), 2-30.

Harold Feiveson, M. V. Ramana and José Goldemberg, "Managing the Civilian Nuclear Fuel Cycle," *Global Fissile Material Report 2007*, International Panel on Fissile Materials, Princeton (2007), 82-91.

M. V. Ramana, "Feeding the Nuclear Fire: Resuming Nuclear Cooperation with India," in Wade L. Huntley and Karthika Sasikumar, eds., *Nuclear Cooperation with India: New Challenges, New Opportunities* (Vancouver, Canada: Simons Center for Disarmament and Non-Proliferation Research, 2006), 23-27.

Zia Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana, "Fissile Materials in South Asia: The Implications of the U.S.-India Nuclear Deal," International Panel on Fissile Materials Research Report no. 1 (September 2006), 3-35.

M. V. Ramana, "India: A Nuclear Update," Greenpeace Report (May 2003), 1-4.

Andrew Lichterman, Zia Mian, M. V. Ramana, and Jürgen Scheffran, "Beyond Missile Defense," International Network of Engineers and Scientists Against Proliferation/Western States Legal Foundation Briefing Paper (March 2002), 1-10.

Zia Mian, M. V. Ramana, and R. Rajaraman, "Risks and Consequences of Nuclear Weapons Accidents in South Asia," Princeton University/Center for Energy and Environmental Studies Report no. 326 (September 2000), 1-34.

M. V. Ramana, "Bombing Bombay? Effects of Nuclear Weapons and a Case Study of a Hypothetical Explosion," International Physicians for the Prevention of Nuclear War, Cambridge, MA (1999), 5-54.

Conferences

M. V. Ramana, Matthias Englert, and Friederike Frieß, "Accident Risks for High Temperature Reactors," in *1st International Conference on Nuclear Risks*, (April 16-17, 2015), Vienna

Monamie Bhadra, Caitlin Stronell, and M. V. Ramana, "The Impact of Fukushima and Chernobyl on India's Anti-Nuclear Movements," in *Traveling Norms and the Politics of Contention*, (October 25, 2013), Zurich University, 1-9.

Books

Authored

The Power of Promise: Examining Nuclear Energy in India (New Delhi: Penguin Books India, 2012); 313 pages + 55 page bibliography.

Edited

Prisoners of the Nuclear Dream, Edited Volume with C. Rammanohar Reddy (New Delhi: Orient Longman, 2003); 455 pages + 35 page bibliography.

Chapters

M. V. Ramana and Amy King, "A new normal? The changing future of nuclear energy in China," in Peter van Ness and Mel Gurtov, eds., *Learning from Fukushima* (Canberra: Australian National University Press, 2017), 103-132.

M. V. Ramana, "Second life or Half-life? The Contested Future of Nuclear Power and its Potential Role in a Sustainable Energy Transition," in Florian Kern, ed., *Palgrave Handbook of the International Political Economy of Energy Part IV: Energy Transitions* (London: Palgrave Macmillan, 2016), 363-396.

Ali Ahmad and M. V. Ramana, "Prospects for Nuclear Power in the GCC," in Gawdat Bahgat, ed., *The Changing Energy Landscape in the Gulf: Strategic Implications* (Geneva: The Gulf Research Center, 2015), 55-72.

M. V. Ramana, "Absurd Confidence: Risk and Nuclear Power in India," in Rajeev Gowda and Raphaelle Moor, eds., *India at Risk* (New Delhi: Oxford University Press, June 2014), 227-249.

M. V. Ramana, "Scientists and India's Nuclear Bomb," in Pervez Hoodbhoy, ed., *Confronting the Bomb: Pakistani and Indian Scientists Speak Out* **(**Karachi: Oxford University Press, 2012), 1-37

Zia Mian, R. Rajaraman, and M. V. Ramana, "The Infeasibility of Early Warning," in Pervez Hoodbhoy, ed., *Confronting the Bomb: Pakistani and Indian Scientists Speak Out* **(**Karachi: Oxford University Press, 2012), 237-252.

Matthew McKinzie, Zia Mian A.H. Nayyar, and M. V. Ramana, "What Nuclear War Could Do to South Asia," with in Pervez Hoodbhoy, ed., *Confronting the Bomb: Pakistani and Indian Scientists Speak Out* **(**Karachi: Oxford University Press, 2012), 267-276.

F. von Hippel, M. Bunn, A. Diakov, M. Ding, R. Goldston, T. Katsuta, M. V. Ramana, T. Suzuki and Y. Suyuan, "Chapter 14 - Nuclear Energy," in *Global Energy Assessment - Toward a Sustainable Future* (Cambridge, UK and New York, NY, USA: Cambridge University Press, 2012), 1069-1130.

Shoibal Chakravarty and M. V. Ramana, "The Hiding Behind the Poor Debate: A Synthetic Overview," in Navroz Dubash, ed., *Handbook on Climate Change and India: Development, Politics and Governance* (New Delhi: Oxford University Press & London: Earthscan, 2011), 218-229.

M. V. Ramana and J. Y. Suchitra, "Ignoring the Costs: Energy Planning and the Dismal Economics of Nuclear Power in India," in Angela Guimaraes Pereira and Silvio Funtowicz, eds., *Science for Policy: Opportunities and Challenges* (New Delhi: Oxford University Press, 2009), 253-271.

M. V. Ramana, "India's Nuclear Enclave and the Practice of Secrecy," in Itty Abraham, ed., *Nuclear Power and Atomic Publics* (Bloomington, Indiana: Indiana University Press, 2009), 41-67.

M. V. Ramana and J. Y. Suchitra, "The Many Phases of Nuclear Insecurity," in Anant Sudarshan and Ligia Noronha, eds., *India's Energy Security* (New Delhi: Routledge, 2009), 207-222.

M. V. Ramana, "Nuclear Power in India: Failed Past, Dubious Future," in Henry Sokolski, ed., Gauging U.S.-Indian Strategic Cooperation, Nonproliferation Policy Education Center, Washington, D.C., (Carlisle Barracks, PA : Strategic Studies Institute, U.S. Army War College, 2007), 71-98

M. V. Ramana and Zia Mian, "The Nuclear Confrontation in South Asia," *SIPRI Yearbook 2003: Armaments, Disarmament and International Security* (Oxford: Oxford University Press, 2003), 195-212.

M. V. Ramana and Surendra Gadekar, "The Price we Pay: Environmental and Health Impacts of Nuclear Weapons Production and Testing," in M. V. Ramana and C. Rammanohar Reddy, eds. *Prisoners of the Nuclear Dream* (New Delhi: Orient Longman, 2003), 411-441.

M. V. Ramana, "La Trahison des Clercs: Scientists and the India's Nuclear Bomb," in M. V. Ramana and C. Rammanohar Reddy, eds. *Prisoners of the Nuclear Dream* (New Delhi: Orient Longman, 2003), 206-244.

Matthew McKinzie, Zia Mian, A.H. Nayyar, and M. V. Ramana, "The Risks and Consequences of Nuclear War in South Asia," with in Smitu Kothari and Zia Mian, eds. *Out of The Nuclear Shadow* (London: Zed Books & New Delhi: Rainbow Press & Lokayan, 2001), 185-196.

Zia Mian and M. V. Ramana, "A Nuclear Gordian Knot: South Asia and the Limits of Deep Cuts," in Harold A. Feiveson, ed. *The Nuclear Turning Point: A Blueprint for Deep Cuts and De-alerting of Nuclear Weapons* (Washington, D.C.: Brookings Institution Press, 1999), 353-368.

Magazine, Newspaper, and Online Forum Articles

"HTRs will not help establish nuclear power in Jordan," with Ali Ahmad, *The Jordan Times*, May 10, 2018

"The Long Lasting Nature of the Problems at Fukushima: 7 Years of the Disaster and Counting," *Dianuke*, March 20, 2018

"A reminder from Hawaii," with Lauren Borja, *Bulletin of the Atomic Scientists Online*, January 17, 2018

"Canada must change course on nuclear disarmament," with Lauren Borja, *Vancouver Sun*, December 10, 2017

"Canada is missing its chance to shut the gate on nuclear weapons everywhere," with Lauren Borja, *The Conversation*, October 2, 2017

"Small Nuclear Power Reactors: Future or Folly," *The Conversation*, July 24, 2017

"No Indonesian market for SMRs," *Bulletin of the Atomic Scientists Online*, June 28, 2017

"Nuclear Power: Expensive, hazardous and inequitable," with Suvrat Raju, *Hindu*, June 5, 2017

"Ending nuclear lawlessness," with Zia Mian, *Hindu*, April 13, 2017

"Westinghouse: Origins and Effects of the Downfall of a Nuclear Giant," *World Nuclear Industry Status Report*, April 2, 2017

"paromanobik bidyut nipajjanak (Nuclear power is dangerous)" (in Bengali), *Janaswartha Barta*, January 21, 2017

"Jordan's Energy Match: Solar 1, Nuclear 0," with Ali Ahmad, *The Jordan Times*, December 11, 2016

"Future energy: Wasteful reactors," *Deccan Chronicle*, November 20, 2016

"Meghalay-e Uranium khoni-khanan bipajjank (Hazards of mining uranium in Meghalaya)," *Janaswartha Barta* (in Bengali), November 5, 2016

"'A fast reactor at any cost': The perverse pursuit of breeder reactors in India," *Bulletin of the Atomic Scientists Online*, November 3, 2016

"Holding Clean Energy Hostage," with Cathy Kunkel, *Jacobin*, August 23, 2016

"Fast breeder reactors and the slow progress of India's nuclear programme," *Ideas for India*, August 16, 2016

"False Nuclear Hope," with Zia Mian, *Himal*, August 14, 2016

"The Needless Quest for NSG Membership," with Suvrat Raju, *Telegraph*, July 28, 2016

"Nuclear Security Summit: The Road Not Taken," with Zia Mian, *Hindu*, April 19, 2016

"Five Years After the Fukushima Accidents: Thinking about Nuclear Power and Safety," *Dianuke*, March 13, 2016

"'Teething Troubles' at Kudankulam: India Biting More Nuclear Than it Can Chew," *The Wire*, March 8, 2016

"A Radioactive Money Pit: The Hidden Risks of Small-scale Nuclear Reactors," with Sajan Saini, *Harper's Magazine*, February 2016

"Three Cheers (not) for Jaitapur," *Ideas for India*, January 25, 2016

"Moving nuclear reactors inland is a bad idea," with Amy King, *Chinadialogue.net*, January 11, 2016

"Nuclear Salesmen in Paris: Wishful Thinking and Economic Realities," *Economic and Political Weekly Online*, January 2, 2016

"A False Hope," *Bulletin of the Atomic Scientists Online*, December 2015

"The strange love for nuclear energy," with Suvrat Raju, *Hindu*, December 17, 2015

"Ahead of Paris, An Unfavorable Climate for Nuclear?," *Nuclear Intelligence Weekly*, November 20, 2015

"Nuclear Power as Intended Nationally Determined Contribution Document," *Mausam*, November 2015

"Nuclear Power Is No Fix for Climate," World Energy Opinion, *Energyintel.com*, November 2015

"Miles to go: exporting uranium to India," *On Line Opinion*, September 11, 2015, reprinted in *Nuclear Monitor*, September 2015

"An end to reprocessing," *Nuclear Monitor*, August 27, 2015

"Lesson for India: Why reprocessing of spent fuel from nuclear reactors makes little sense," *Economic Times*, August 23, 2015

"Looking Back, Looking Ahead: Plutonium Separation From Power Reactors," with Frank von Hippel, *Nuclear Intelligence Weekly*, August 14, 2015

"Saudi Arabia must not focus on nuclear power," with Ali Ahmad, *Gulf News*, June 25, 2015

"Betting on the Wrong Horse: Fast Reactors and Climate Change," *Mausam*, April-June, 2015, reprinted in *Nuclear Monitor*, December 2015

"Paromanobik Shokti Ki Samadhan? (Is nuclear power the solution?)," *Janaswartha Barta* (in Bengali), May 23, 2015

"No Big Deal," with Suvrat Raju, *Hindu Business Line*, May 1, 2015

"The Forgotten History of Small Nuclear Reactors," *IEEE Spectrum*, May 2015

"Saudi Arabia's expensive quest for nuclear power," with Ali Ahmad, *Nuclear Monitor*, April 2015

"Is nuclear the answer to India's energy crisis?" *SciDev.net*, April 20, 2015

"Profitability without accountability," with Suvrat Raju, *Hindu*, February 16, 2015

"Go slow on fast reactors," *TheHill.com*, February 3, 2015

"Nuclear deal no cause for celebration," with Suvrat Raju, *Hindu*, January 31, 2015

"Does the Middle East Really Need Nuclear Power?," with Ali Ahmad, *Al Monitor*, 25 September 2014 (reproduced in *Yemen Times*, 2 October 2014)

"The Doctrine of the Nuclear Sword," with Zia Mian, *Himal*, September 2014

"Too Much to Ask: Why Small Modular Reactors may not be able to Solve the Problems Confronting Nuclear Power," with Zia Mian, *Nuclear Monitor*, September 2014

"Atomic Power at a Steep Price," with Suvrat Raju, *Daily News & Analysis*, March 27, 2014

"It's better to be safe than sorry," with Suvrat Raju, *Hindustan Times*, February 5, 2014

"Can Nuclear Power Be an Answer to India's Electricity Needs?," *akiomatsumura.com*, November 14, 2013

"The Impasse Over Liability Clause in Indo-U.S. Nuclear Deal," with Suvrat Raju, *IndiaInk Blog, New York Times*, October 15, 2013

"The 2020 Olympics, Fukushima, and Trust," Postscript, *Economic and Political Weekly*, Vol. XLVIII, No. 40, October 5, 2013

"Nuclear Extravagance in Washington," with Suvrat Raju, *Hindu*, September 26, 2013

"The Limited Future of Nuclear Power in India," *Physics and Society*, Vol. 42, No.3, July 2013

"China Must Avoid Costly Trap of Reprocessing Nuclear Fuel," with Frank von Hippel, *Chinadialogue.net*, July 12, 2013

"Whistle Blowers and the Public Interest," *Sanhati.com*, June 25, 2013

"Nuclear Energy: Infeasibility and Unimportance," *Institute of Peace and Conflict Studies* (article on website), June 10, 2013

"Kudankulam: The Unsettled Queries," *LiveMint*, June 5, 2013

"Nuclear Energy – Reassurances Don't Guarantee Safety," *Kafila.org*, April 4, 2013

"Castes and Moulds: Review of *Dispersed Radiance* by Abha Sur," *Himal*, April 2013

"India's Breeder Dreams and Realities," *Nuclear Monitor*, April 2, 2013

"A Very Expensive Proposition," with Suvrat Raju, *Hindustan Times*, February 12, 2013

"Some Challenges of Dealing with Nuclear Waste," *Newsclick* (online magazine), January 24, 2013

"The Problem of Radioactive Waste Disposal," (translated into Kananda) *Vijay Karnataka*, November 24, 2012

"Nuclear Safety Before Vendor Interests," with Suvrat Raju, *Hindu*, October 30, 2012

"India's nuclear power failures warn against uranium exports," *The Conversation*, October 15, 2012

"Where the Mind is Full of Fear: Opposition to the Koodankulam Nuclear Reactor," with Suvrat Raju, *Hindu*, September 19, 2012.

"Flight From Disarmament," *Bulletin of the Atomic Scientists Online*, May 10, 2012

"Nuclear Energy and Democracy," with Suvrat Raju, *Al Jazeera English*, April 25, 2012.

"A New Twist in the Saga of India's Liability Law," with Suvrat Raju, *Nuclear Intelligence Weekly,* April 13, 2012

"In Denial of Fukushima," *Tehelka*, March 17, 2012

Review of *Nucleus and Nation: Scientists, International Networks and Power in India* by Robert Anderson, *Pacific Affairs*, **8**, no. 4 (2011).

"No Power to the People," with Suvrat Raju, *Hindustan Times*, November 29, 2011

"This Power Play Fails to Charm," *Sydney Morning Herald*, November 18, 2011

"Why Kudankulam is Untenable," with Suvrat Raju, *Hindu*, November 12, 2011

"A Nuclear Chain Reaction," with Suvrat Raju, *Times of India*, September 24, 2011

"Managing Spent Nuclear Fuel," with Harold Feiveson, Zia Mian, and Frank von Hippel, *Bulletin of the Atomic Scientists Online*, June 27, 2011

"Strange Love," with Suvrat Raju, *Open Magazine*, May 14, 2011

"Beyond Our Imagination: Fukushima and the Problem of Assessing Risk," *Bulletin of the Atomic Scientists Online*, April 19, 2011

"Nuclear Reality, Damaged Democracy," with Suvrat Raju, *Down to Earth*, April 16, 2011

"The Nature of Nuclear," with A. H. Nayyar and Zia Mian, *Himal*, April 2011

"The Multiple Costs of India's Nuclear Ambitions," with Suvrat Raju, *InfoChange*, April 2011

"Fukushima Lessons," with A. H. Nayyar and Zia Mian, *Dawn*, March 27, 2011

"React on Reactors," with Suvrat Raju, *Hindustan Times*, March 17, 2011

"French Dressing: Nuclear Reactors for Jaitapur," with Suvrat Raju, *Hindustan Times*, December 21, 2010

"No Sweetheart Deal This," with Suvrat Raju, *Hindustan Times*, August 26, 2010

"Moral Hazard of Indemnifying Suppliers," with Suvrat Raju, *Hindu*, August 21, 2010

"To Avoid a Disaster," with Suvrat Raju, *Hindustan Times*, August 15, 2010

"India Nuke Rule Upsets Security in South Asia," with Zia Mian, *Asahi Shimbun*, August 8, 2010

"For Whom the Nuclear Liability Bill," with Suvrat Raju, *Nai Dunia (Hindi)*, April 17, 2010

"Nuclear power and public safety,"with Ashwin Kumar, *Third World Resurgence*, no. 235, 2010

"India's Renaissance: Imperiled by Weak Safety Standards?" *Uranium Intelligence Weekly*, January 19, 2010

"The Future of Nuclear Power in India," *India in Transition*, January 4, 2010

"Life in a Radiation Zone," *Down to Earth*, January 1, 2010

"The Impact of the Indo-US Nuclear Deal on the NPT and the Global Climate Regime," *Heinrich* Böll *Stiftung – Foreign Affairs & Security*, December 8, 2009

"A Nuclear and Sustainable Energy Reading List," with Zia Mian, *Bulletin of Atomic Scientists*, November-December, 2009

"India's Evolving Climate Change Strategy," with Shoibal Chakravarty, *Climate Science and Policy*, November 13, 2009

"The Safety Inadequacies of India's Fast Breeder Reactor," with Ashwin Kumar, *Bulletin of Atomic Scientists Online*, July 21, 2009

"Nuclear Growth Projections," *Dainik Janambhumi (Assamese)*, January 7, 2009

"Globalization of the Nuclear Industry," with Andrew Lichterman, *Strategic Affairs*, December 15, 2008

"Rushing into the Wrong Future: The U.S.-India Nuclear Deal, Energy and Security," with Andrew Lichterman, *Dissident Voice*, September 20, 2008

"Implications of the NSG Waiver Decision," *Dainik Janambhumi (Assamese)*, September 13, 2008

"False Premise: Indo-U.S. Nuclear Deal," in two installments, *Siliconeer*, August and September, 2008

"Misleading Propaganda in Support of the Nuclear Deal," *Dainik Janambhumi (Assamese)*, July 16, 2008

"The Indian Approach to Climate and Energy Policy," with Divya Badami Rao, *Bulletin of the Atomic Scientists Online*, July 3, 2008

"What is Wrong with Testing Missiles?," *Dainik Janambhumi (Assamese)*, June 14, 2008

"An Offer to Refuse," *Dainik Janambhumi (Assamese)*, May 18, 2008

"Deeper into the Morass: Ten Years After Pokharan," *Hindu*, May 11, 2008

"Remembering Chernobyl," *Dainik Janambhumi (Assamese)*, April 28, 2008

"The Choices Involved in the Nuclear Deal," *Phalanx*, April 2008

"The Physical Basis of Climate Change," *Dainik Janambhumi (Assamese)*, March 13, 2008

"A Land Dispute Ready to Explode: Uranium Mining in Meghalaya," *Hindustan Times*, February 2, 2008

"Nuclear Energy: A Costly Affair," with J. Y. Suchitra, *Hosatu (Kannada)*, January 2008

"Nuclear safety lessons from Japan's summer earthquake," with Ashwin Kumar, *Bulletin of the Atomic Scientists Online*, December 5, 2007

"The Costs of Nuclear Energy," *Dainik Janambhumi (Assamese)*, November 7, 2007

"Fast Breeder of Expenditure?" with J. Y. Suchitra, *Hindustan Times*, October 23, 2007

"The Nuclear Deal and Fundamental Choices," *Dainik Janambhumi (Assamese)*, September 10 & 11, 2007

"Koodankulam Goes Nuclear," with Manju Menon, *Himal Southasian*, August 2007

"Address Local Concerns at Koodankulam," with Manju Menon, *Tribune (Chandigarh)*, August 8, 2007

"Triumph of Fear," with Zia Mian, *Bulletin of the Atomic Scientists*, July 2007

"More Missiles than Megawatts," *IEEE Spectrum*, July 2007

"Home, Next to N-reactor," with Praful Bidwai, *Tehelka*, June 23, 2007, translated and published in *Manida Urimai Kangani (Tamil)*, July 2007

"Uranium Mining: Health and Ecological Impact," *Dainik Janambhumi (Assamese)*, June 16, 2007

"Fight Against Global Warming: N-energy won't help," with G. Ananthapadmanabhan, *Deccan Herald*, May 12, 2007

"Three Boos," *Peace Now*, May 2007

"Feeding Potential for South Asia's Nuclear Fire," with Zia Mian and Frank von Hippel, *Asahi Shimbun*, March 5, 2007 (Japanese) and March 29, 2007 (English)

"Dealing with the Nuclear Deal," *Peace Now*, November 2006

"Citizens Inputs on Power Tariffs," *India Together*, November 24, 2006

"Editorial," Special issue on Chernobyl and the Future of Nuclear Power, *Peace Now*, June 2006

"Chernobyl: The Politics of Counting Deaths," *Peace Now*, June 2006

"Flaws in the Pro-nuclear Argument," with J. Y. Suchitra, *InfoChange Agenda* **5**, (2006)

"Let's Not Chase the Atom," *Down to Earth*, March 31, 2006

"Don't Switch over to Nuclear Power," *The Economic Times*, March 10, 2006

"Hiroshima and Nagasaki: Experiments in Nuclear Mass Murder," *Peace Now*, August 2005

"India-US nuclear agreement: a Bad Deal," *The Friday Times*, July 29, 2005

"Nuclear Power: No Solution to Global Warming," *The Friday Times*, July 1, 2005

"Nuclear Power is not Cheap," with Amulya Reddy, *The New Indian Express*, June 20, 2005

"NPT RevCon: Challenges of Disarmament," *The Friday Times*, April 22, 2005

"Talking Peace, Making War," with Zia Mian and A. H. Nayyar, *The News*, January 8, 2005

"A Fast Breeder of Danger," *Indian Express*, September 7, 2004

"Steps for Nuclear Talks," with Zia Mian, A. H. Nayyar and R. Rajaraman, *The News*, July 2, 2004

"When Early Warning is no Warning," with Zia Mian and R. Rajaraman, *The Hindu*, July 2, 2004

"Reducing Nuclear Risk," with R. Rajaraman, *The Hindu*, June 4, 2004

"Reinforcing Nuclear Secrecy," *The Daily Times*, February 5, 2004

"Some Things to Agree on," with Zia Mian, A. H. Nayyar and Sandeep Pandey, *The Daily Times*, January 2, 2004

"Nuclear Terrorism: the Greater Dangers," *The Daily Times*, December 18, 2003

"Climate Change and Developing Countries," *The Daily Times*, December 4, 2003

"Climate Change Failure: the Underlying Causes," *The Daily Times*, November 21, 2003

"The Arms Race Continues," *The Daily Times*, October 23, 2003

"Need for Nuclear Transparency," *The Daily Times*, September 25, 2003

"Electricity Sector Restructuring," *The Daily Times*, September 11, 2003

"Nuclear Disarmament after Iraq," *The Daily Times*, July 31, 2003

"Reprocessing: the Cons," *Outlook (web edition)* July 25, 2003

"Enduring Nuclear Legacies," *The Daily Times*, July 17, 2003

"Steps to Peace," *The Daily Times*, May 22, 2003

"Remembering the Chernobyl Catastrophe," *The Daily Times*, April 24, 2003

"Compounding Mistakes: New Reactor at Chashma," *The Daily Times*, April 10, 2003

"Assessing Emergency Plans," *The Daily Times*, March 13, 2003

"Nuclear Resurgence in the US," *The Daily Times*, February 27, 2003

"India's Force in Being," *The Daily Times*, February 6, 2003

"Phasing Out Nuclear Energy in Europe," *The Daily Times*, January 30, 2003

"Military Planning and Nuclear Weapons," *The Daily Times*, January 16, 2003

"India's Nuclear Command Authority," *The Daily Times*, January 9, 2003

"Reckless Challenges," *The Daily Times*, December 5, 2002

"Following the US Lead," *The Daily Times*, November 14, 2002

"False Alarms and Early Warning Systems," *The Daily Times*, November 7, 2002

"North Korea's Negotiating Strategy," *The Daily Times*, October 31, 2002

"Deterrence: Hope and Reality," *The Daily Times*, October 3, 2002

"Nuclear Deterrence: The Inside Look," *The Daily Times*, September 26, 2002

"Shared Understandings and Deterrence," *The Daily Times*, September 12, 2002

"Impacts of Underground Nuclear Tests," *The Daily Times*, August 23, 2002

"The Arrow Deal: India, Israel and the US," *The Daily Times*, August 8, 2002

"Indo-Pak Military Crises – Some Fallouts," *The Daily Times*, July 25, 2002

"Censorship in the Nuclear Age," *The Hindu*, July 19, 2002

"Radioactive Fallout from Nuclear Testing," *The Daily Times*, July 18, 2002

"Bush-Putin Nuclear Treaty," *The Daily Times*, July 4, 2002

"Censoring Nuclear Truths," *The Daily Times*, June 27, 2002

"The Illogic of Civil Defense," *The Daily Times*, June 13, 2002

"Tactical Nuclear Weapons: Another Firebreak," *The Daily Times*, June 6, 2002

"Profiting from Arms Sales and Death," *The Daily Times*, May 30, 2002

"Nuclear Instability and Militancy," *The Daily Times*, May 23, 2002

"Missiles and the Fast Delivery of Nuclear Destruction," *The Daily Times*, May 16, 2002

"Looking Back at Pokharan II," *Outlook (web edition)*, May 13, 2002

"Dubious Achievements of the BJP Government," *The Daily Times*, May 9, 2002

"Nuclear Non-Proliferation Treaty: Stalemate again," *The Daily Times*, April 25, 2002

"The US Contempt for International Treaties," *The Daily Times*, April 18, 2002

"Reviewing the Nuclear Non-Proliferation Treaty," *The Daily Times*, April 11, 2002

"Reality Behind the Smoke Screen: US Nuclear Posture Review," *The Friday Times*, April 5-11, 2002

"In the Event of a Nuclear War," *Mantram: For the Ambitious South Asian Professional*, March 2002

"India-Pakistan Standoff: Recalling October 1962," *The Friday Times*, February 22-28, 2002

"A Nuclear Wedge," *Frontline*, December 8, 2001

"India, Pakistan and the Bomb," with A. H. Nayyar, *Scientific American*, December 2001

"Yet Another Nuclear Danger," with Zia Mian and R. Rajaraman, *Frontline*, August 17, 2001

"Fast Breeders: Tall Promises, Poor Performance," *The Hindu*, July 16, 2001

"What they can Agree on," *The Hindu*, July 10, 2001

"The New Texas Ranger and his Guns," with Andrew Lichterman, *Frontline*, June 8, 2001

"Fast-breeder Reactors - A Dying Breed," *The Hindu*, May 28, 2001

"The Bomb of the Blue God," *South Asian Magazine for Action and Reflection*, Winter/Spring 2001

"Slow, Silent Killer," *Frontline*, February 3, 2001

"New Nukes, Old Speak," *The Friday Times*, October 27, 2000

"The Concorde and the Nuclear Reactor," *Himal*, September 2000

"Ending the n-race," *The Hindu*, May 25, 2000

"Old Weapons, New Contestants," *IEEE Spectrum*, March 2000

"Scientists and the Indian Bomb," *Anubhav*, February 2000

"The Question of Nuclear Yield," *Frontline*, January 21, 2000

"Dangerous Encounters: Nuclear Reactor Accidents," *The Hindu*, November 21, 1999

"Organizing in India Against the Bomb," *Vital Signs*, Vol. 12, Issue 2, November 1999

"Sweeping Charges: The Cox Report and Nuclear Espionage," *Frontline*, October 22, 1999

"Draft Nuclear Doctrine," *Dainik Bhaskar (Hindi)*, September 1999

"A Recipe for Disaster," *The Hindu*, September 9, 1999

"Disturbing Questions: On the Heavy Water Leak at the Madras Atomic Power Station," *Frontline*, June 4, 1999

"Underground Tests: Ravaging Nature," *The Hindu Survey of the Environment '99* (June 1999)

"Heads They Win, Tails We All Lose," *Dainik Bhaskar (Hindi)*, June 1999

"Nuclear Tests: the Long Term Fallouts," *The News on Sunday* (Pakistan) May 2, 1999

"For a Just Peace: The Anti-Nuclear Movement in India," *Social Science Research Council Newsletter* **12** (May 1999)

"Health and Environmental Effects of Underground Nuclear Tests," *Dainik Bhaskar (Hindi)*, March 1999

"Radiation Perils to Workers: Experiences from the United States," *Dainik Bhaskar (Hindi)*, February 1999

"Reject the Hydrogen Bomb!," *Dainik Bhaskar (Hindi)*, January 1999

"Did India Test an H-bomb?," with Frank von Hippel, *Federation of American Scientists Public Interest Report* **52** No. 1, January/February 1999

"Does India Need the H-bomb?," with Frank von Hippel, *The Hindu*, December 23, 1998

"Nuclear Weapons and Security," *Dainik Bhaskar (Hindi)*, December 1998

"The Indian Nuclear Bomb – Long in the Making," *Precis* **9** No. 3 Fall 1998

"If? Bombing Bombay," *Himal* August 1998

"India's Changing Nuclear Policy," *Peace Magazine* XIV, January/February 1998

"A Fissile Material Cutoff Treaty," *Peace Magazine* XII, May/June 1996

PROFESSIONAL MEETINGS

- "Challenges of Small Modular Reactors," Presentation at Panel on "Emerging Technologies for Small-scale Grids", Singapore International Energy Week, Singapore, October 27, 2017

- "Nuclear Energy and Nuclear Disarmament: Can the two co-exist?," Presentation at the Gathering in the Shadows of a Nuclear Winter Conference, South Asian Network for Secularism and Democracy and Institute for the Humanities, Simon Fraser University, Vancouver, September 9, 2017

- "Global and Regional Economics of Nuclear and Renewable Energy," Presentation at Workshop on The Future of Nuclear Energy in the Middle East, International Panel on Fissile Materials and American University of Beirut, Beirut, March 15, 2017

- "Nuclear Energy in Saudi Arabia: Necessary? Economically Competitive?," Presentation at NPEC Public Policy Fellowship Retreat, Nonproliferation Policy Education Center, Washington, D.C., March 4, 2017

- "Linkages Between Nuclear Energy and Nuclear Weapons," Presentation (over Skype) at Workshop on The Nuclear-Climate Nexus and Sustainable Peace, International Peace Bureau World Congress, Berlin, October 1, 2016

- "Emerging Reactor and Fuel Cycle Technologies, Including Associated Safety, Security, and Safeguards Risks," Presentation at Workshop on Managing Risks Associated with Global Nuclear Energy Expansion: Emerging Challenges and Cooperative Solutions, George Washington University, Washington, D. C., May 5, 2016

- "Reprocessing and Breeder Reactors: The Case of India," Presentation at Meeting of the International Panel on Fissile Materials, American Association for the Advancement of Science, Washington, D. C., March 14-15, 2016

- "Ethical Concerns Regarding Nuclear Energy: Weapons, Accidents, Wastes, Costs, and Democracy," Workshop on Ethics and Governance of Energy Technologies, Eindhoven University of Technology, Netherlands, January 15, 2016

- Co-convenor, Working Group on "Civilian Nuclear Energy, Energy Resources, and International Cooperation," 61st Pugwash Conference on Science & World Affairs, Nagasaki, Japan, November 1-5, 2015

- "Small Modular Reactors in the United States," Workshop on Nuclear Power And Small Modular Reactors In Indonesia: Potential And Challenges, Indonesian Institute of Energy Economics, Jakarta, June 25, 2015

- "The Challenges of Nuclear Safety," International Workshop on Emerging Energy Scenarios in the Middle East, Munib and Angela Masri Institute of Energy and Natural Resources,American University, Beirut, May 22, 2015

- "Accident Risks for High Temperature Reactors," 1st International Conference on Nuclear Risks, Vienna, April 16-17, 2015

- "Taking Sides on the 'Double Movement'," Polanyi Conference on Science and Social Responsibility, University of Toronto, November 15, 2014

- "Nuclear Power in Today's Energy and Environmental Discourse," Workshop on New Studies in Ecology and Environment, New Delhi, India, August 23, 2014

- "Liability" and "Waste Management," two talks at Workshop on Nuclear Power in East Asia: The Costs and Benefits, Australian National University, Canberra, Australia, August 12-14, 2014

- "The State of the SMR Market," Third Trilateral Meeting, Carnegie Mellon University, Pittsburgh, May 8-9, 2014

- "Arguing from the Periphery," American Physical Society Annual Meeting, Savannah, GA, April 6, 2014

- "Resource Requirements and Proliferation Risks Associated with Small Modular Reactors," Panel on Opportunities and Challenges for Nuclear Small Modular Reactors, American Association for the Advancement of Science Annual Meeting, Chicago, February 15, 2014

- "Global Context for Nuclear Power," Conference on Nuclear Technology, Nuclear Energy and a ME WMD-free Zone, Doha, Qatar, October 27, 2013

- "The Impact of Fukushima and Chernobyl on India's Anti-Nuclear Movements," Conference on Traveling Norms and the Politics of Contention, Zurich, Switzerland, October 25, 2013

- "Small Modular Reactors: Uranium Resource Requirements, Waste Generation and Proliferation Risk Assessment," Presentation at the 21st International Conference on Nuclear Engineering, Chengdu, China, July 29-August 2, 2013

- "Fukushima Nuclear Accident: Shortcomings of Safety Regulation and Lessons Learned," Panel Discussion at the Carnegie International Nuclear Policy Conference, Washington, D.C., April 8, 2013

- "Whither Nuclear Power?" Panel Discussion at the Carnegie International Nuclear Policy Conference, Washington, D.C., April 8, 2013

- "'One in infinity': Assessing Nuclear Risks in India," Presentation at the Panel on "India at Risk: Capacity, Institutions and Expertise", Society for Risk Analysis 2012 Annual Meeting, San Francisco, December 12, 2012

- "How about Domestic Emission Inequities? The Case of India," Presentation at the International Conference on Inequality and Sustainability, Stockholm Environmental Institute & Center for International Environment and Resource Policy, Boston, November 9, 2012

- "Proliferation Risks Associated with Small Modular Reactors," Presentation at the "Summer Symposium on Science and World Affairs", Organized by the Union of Concerned Scientists, Princeton, July 9, 2012

- "India and Nuclear Transparency," Presentation at the Workshop on "Transparency", Organized by the International Panel on Fissile Materials, Princeton, March 31, 2012

- "Nuclear Safety and Security in India," Presentation at the Panel Discussion on Nuclear Policy of Key Countries, Seoul National University, Seoul, South Korea, March 22, 2012

- "Indian Fallout: Public Protest and Organizational Strategies in the Aftermath of the Fukushima Accidents," Presentation at Panel Discussion on Nuclear Energy After Fukushima: Japan and Beyond, Association of Asian Studies Conference, Toronto, March 18, 2012

- "Nuclear Power in India: Implications of Fukushima," Presentation at the Panel on Nuclear Power: One Year after Fukushima, Amecian Physical Society Meeting, Boston, March 1, 2012

- "India's Nuclear Plans: Can they be Realized?," Presentation at the Workshop on "Reprocessing", Organized by the International Panel on Fissile Materials, Tokyo, January 20, 2012

- "Prospects for India's Breeder Program," Presentation at the Workshop on "Nuclear Fuel Cycle Issues in Asia", Organized by the International Panel on Fissile Materials, Tokyo, March 19, 2010

- "Inherently Ambiguous? The Limits of Nuclear Accident Scenarios and Safety Analyses," Meeting on "Knowledge Society Debates", Organized by the STEPS Centre, University of Sussex, National Institute of Advanced Studies, Bangalore, January 8, 2009

- "Some Challenges for Nuclear Power in Developing Countries," Presentation at Conference on "New Generation Nuclear: From policy to implementation," Organized by Chatham House, London, November 17-18, 2008

- "Nuclear Power in India: Perspectives and Challenges," Presentation at Conference on "The nuclear energy revival: regional perspectives and governance challenges," Organized by Centre for International Governance Innovation & Canadian Centre for Treaty Compliance, Waterloo, November 6-7, 2008

- "More than Desirable: Some Necessary, but not Sufficient, Conditions for Nuclear Expansion," Presentation at the Conference on The Future of Nuclear Energy, Organized by the Bulletin of the Atomic Scientists, Argonne National Laboratory, and the University of Chicago, Chicago, September 25-26, 2008

- "Nuclear Power and Energy Security in India," Presentation at Meeting on "The Proposal for Nuclear Trade with India," Organized by Heinrich Böll Foundation and Arms Control Association, Berlin, May 13, 2008

- "Some Implications of the US-India Nuclear Deal," Presentation at the NGO Panel on "The US-India Nuclear Deal and the NPT," Nuclear Non Proliferation Treaty Preparatory Committee Meeting, United Nations, Geneva, May 2, 2008

- "Fissile Material Implications of the US-India Nuclear Deal," Presentation at the Annual Meeting of the German Physical Society, Berlin, February 29, 2008

- "Nuclear Safety," Presentation at the Centre for Interdisciplinary Studies on Environment and Development Advisory Committee Meeting, Bangalore, January 11, 2008

- "Climate Change and Nuclear Power in Developing Countries," Presentation at "Nuclear Energy: Myth and Reality," Side event at 13th Conference of Parties to the United Nations Framework Convention on Climate Change, Organized by Heinrich Böll Foundation, Nusa Dua, Bali, December 13, 2007

- "Infeasible and Undesirable: A Nuclear Comeback and Climate Security," Presentation at 2nd TERI-KAF Conference on "Energy, Climate, and Security: The Inter-Linkages," Organized by The Energy and Resources Institute and Konrad Adaneur Foundation, Goa, October 13 - 14, 2007

- "Nuclear Reactors: Unsafe at any Price," Presentation at the International Conference on "Indo-US Nuclear Deal," Organized by the Heinrich Böll Foundation, CNDP, and PEACE, New Delhi, August 31-September 1, 2007

- "The U.S. India Nuclear Deal: Debates and Implications," Presentation at the Meeting on "Forging a New Consensus for the NPT," Article VI Forum, Vienna International Center, Vienna, March 29, 2007

- "Nuclear Energy: Projections and Economics," Presentation at Workshop on Power Sector Reforms and Regulation in India, Prayas, Pune, March 22-23, 2007

- "Economic and Environmental Costs of Nuclear Power," Presentation at the Ninth Biennial Conference of the International Society of Ecological Economics, New Delhi, December 16-18, 2006

- "Nuclear Economics in a Developing Country: The Case of India," Presentation at the Conference on The Future of Nuclear Energy, Organized by the Bulletin of the Atomic Scientists, Argonne National Laboratory, and the University of Chicago, Chicago, November 1-2, 2006

- "Nuclear Energy and Climate Change," Presentation at the Workshop for Journalists on Energy and Climate Change, Organized by PANOS South Asia, New Delhi, July 5, 2006

- "Feeding the Nuclear Fire," Presentation at the Conference on International Nuclear Cooperation with India, Simons Centre for Disarmament, University of British Columbia, Vancouver, November 22, 2005

- "India's Nuclear Enclave and the Practice of Secrecy," Presentation at the Second Workshop on "Culture, Society and Nuclear weapons in South Asia," Social Science Research Council, Washington, D.C., August 28-29, 2005

- "An Estimate of India's Uranium Enrichment Capacity," Presentation at the 17th International Summer Symposium on Science and World Affairs, Princeton, July 23-31, 2005

- Discussant, First Workshop on "Culture, Society and Nuclear weapons in South Asia," Social Science Research Council, Amsterdam, May 9-11, 2005

- "Nuclear Power: the Department of Atomic Energy's Plans and Constraints," Presentation at the Consultation Meeting on Strategies to Realize a Non-nuclear India organized by Citizens for Alternatives to Nuclear Energy and Centre for Interdisciplinary Studies in Environment and Development, Bangalore, January 29, 2005

- Coordinator, Environmental Sustainability Group, Workshop on "Neglected Dimensions of Electricity Sector Policies: Equity, Sustainability, and Institutions and Governance," Prayas, Pune, January 11-12, 2005

- "India and Nuclear Secrecy," Presentation at the Conference on "Transparency as a Pre-requisite of Arms Control," Peace Research Institute, Bensheim, November 19-20, 2004

- "Nuclear Energy and Security," Presentation at the Workshop on "The Challenge of Hiroshima: Alternatives to Nuclear Weapons, Missiles, Missile Defenses, and Space Weaponization in a Northeast Asian Context," International Network of Engineers and Scientists Against Nuclear Weapons, Hiroshima, October 8-11, 2004

- "Energy and Environmental Sustainability," Presentation at the National Seminar on Integrating Environmental Sustainability with Economic Development, Maharani's Arts College for Women, Bangalore, August 26, 2004

- "The Cost of Electricity from Indian Pressurised Heavy Water Reactors," Presentation at the Centre for Interdisciplinary Studies on Environment and Development Advisory Committee Meeting, Bangalore, January 12, 2004

- "Effects of Nuclear Explosions," Lecture at the Workshop on "Defence, Technology and Cooperative Security in South Asia", Regional Centre for Strategic Studies, Shanghai, December 3-13, 2003

- "Problems with Nuclear Early Warning Systems in South Asia," Lecture at the Workshop on "Defence, Technology and Cooperative Security in South Asia", Regional Centre for Strategic Studies, Shanghai, December 3-13, 2003

- "Nuclear Weapons Effects," Presentation at the Institute for Energy and Environmental Research Technical Training Workshop, Takoma Park, Maryland, June 19, 2003

- "Nuclear South Asia," Talk at Panel on "War and Public Health," Presentation at the American Public Health Association 130th Annual Meeting & Exposition, Philadelphia, November 11, 2002

- "Under the Nuclear Shadow," Discussion at Middlesex County College, October 31, 2002

- "Dangers of Nuclear War and Paths to Nuclear Weapons Abolition," Presentation at the American Friends Service Committee Conference on "Paths to a Just and Secure Future," Boston, October 11, 2002

- "Nuclear South Asia," Overview Lecture at the 1st International Professional Meeting of Independent Technical Security Analysts, Chicago, July 23-24, 2002

- Invited "Shadow Expert" at the SANITY (Students Against Nuclear Insanity and for Tomorrow's Youth) Youth Caucus at the Nuclear Non Proliferation Treaty Preparatory Committee Meeting, United Nations, New York, April 17, 2002

- "The Arms Race in South Asia," Presentation at the NGO Panel on "The Shape of Things to Come," Nuclear Non Proliferation Treaty Preparatory Committee Meeting, United Nations, New York, April 12, 2002

- "Alternatives to Missile Defense," Briefing for Delegates, NGOs and Press at the Nuclear Non Proliferation Treaty Preparatory Committee Meeting, United Nations, New York, April 11, 2002

- "Effects of Nuclear Explosions and Nuclear War in South Asia," Lecture at the Workshop on "Defence, Technology and Cooperative Security in South Asia", Regional Centre for Strategic Studies, Kalutara, Sri Lanka, January 5-14, 2002

- "Plutonium Dispersal and Health Hazards from Nuclear Weapon Accidents," Lecture at the Workshop on "Defence, Technology and Cooperative Security in South Asia", Regional Centre for Strategic Studies, Kalutara, Sri Lanka, January 5-14, 2002

- "Beyond Missile Defense: Arguments," Presentation at the 13th International Summer Symposium on Science and World Affairs, Berlin, July 21-30, 2001

- "The Missile Race in Critical Regions: Is there a way out?," Presentation at the Workshop on "Moving Beyond Missile Defense", International Network of Engineers and Scientists Against Nuclear Weapons, Santa Barbara, March 19-21, 2001

- "Is there a Missile Threat? The Dynamics of Missile Proliferation and the State of Missile Control," Presentation at the Workshop on "Moving Beyond Missile Defense", International Network of Engineers and Scientists Against Nuclear Weapons, Santa Barbara, March 19-21, 2001

- "Ballistic Missile Disarmament," Presentation at the Panel on "Outer Space: Disarmament Issues," Organized by the NGO Committee on Disarmament, Disarmament Week, United Nations, October 19, 2000

- "Why Nuclear Disarmament," Presentation at the Alliance for Nuclear Accountability Meeting, Amarillo, September 23, 2000

- "Plutonium Dispersion and Health Hazards from Nuclear Weapons Accidents," Presentation at the 12th International Summer Symposium on Science and World Affairs, Moscow, Russia, August 23-31, 2000

- "Scientists and Radiation Protection: A History," Presentation at the NGO Panel on "Health, Environment, Science and Society: Professional Responsibility in the Nuclear Age," Nuclear Non-Proliferation Treaty Review Conference, United Nations, New York, May 15, 2000

- "Environmental Aspects of the Nuclear Fuel Cycle," Presentation at the NGO Panel on "The Toxic Legacy of the Nuclear Age," Nuclear Non-Proliferation Treaty Review Conference, United Nations, New York, May 4, 2000

- "Scientists and Ideology," Presentation at the NGO Panel on "Personal Responsibility in the Nuclear Age," Nuclear Non-Proliferation Treaty Review Conference, United Nations, New York, May 1, 2000

- "NPT Forecast: Cloudy or Sunny," Presentation at the NGO Presentation in preparation for the Nuclear Non-Proliferation Treaty Review Conference, United Nations, New York, April 18, 2000

- "The Future of Post-Nuclear South Asia," Presentation at the Conference on "Rethinking the Past, Shaping the Future: Partition, History and Identity," South Asian Students Association of Smith College, Northampton, MA, March 25, 2000

- Overview presentation at the workshop (jointly organized with Srirupa Roy, New York University) on "Nuclear Understandings: Science, Society, and the Bomb in South Asia," Dhaka, February 17, 2000

- Overview presentation at plenary discussion on "Nuclear Policy and Understandings in India" at the 13th Annual SSRC-MacArthur Foundation Fellows' The Conference, New Delhi, August 19-23, 1999

- "Health Effects of Reactor Accidents," Presentation at the 11th International Summer Symposium on Science and World Affairs, Shanghai, China, July 28 - August 5, 1999

- "Regional Proliferation," NGO Presentation at the Nuclear Non Proliferation Treaty Preparatory Committee Meeting, United Nations, New York, May 10-21, 1999

- "Nuclear Capabilities of India," Presentation at the session on "Physics and Disarmament" at the 63rd Annual Meeting of the German Physical Society, Heidelberg, March 18, 1999

- Keynote Speaker, Symposium on De-alerting of Nuclear Weapons, Organized by The United Nations Department of Disarmament Affairs, New York, October 26, 1998

- "Radioactivity Releases from Underground Nuclear Tests," Presentation at the 10th International Summer Symposium on Science and World Affairs, Cambridge, Massachusetts, USA, July 13-21, 1998

- "India's Nuclear Tests: Some Technical Aspects," Presentation at the 10th International Summer Symposium on Science and World Affairs, Cambridge, Massachusetts, USA, July 13-21, 1998

- "Effects of a Nuclear Explosion," Presentation at the Institute for Energy and Environmental Research Technical Training Workshop, Takoma Park, Maryland, July 7-12, 1998

- Discussant, Panel Discussion on "India, Pakistan and Global Nuclear Disarmament," Sponsored by Congresswoman Barbara Lee and Congressman John Conyers and the Institute for Policy Studies, Rayburn House Office Building, Washington, D.C., June 25, 1998

- "India's Nuclear Tests," Presentation at the 12th Annual SSRC-MacArthur Foundation Fellows' Conference, San Salvador, May 17-23, 1998

- Invited Specialist to discuss "Agreements on controlling the components: a fissile material cut-off" at the International Consultation on "Global Security and Nuclear Disarmament" organized by the United Services Institution, Delhi and the Oxford Research Group, U.K., Neemrana, March 3-6, 1998.

- "Serving a Nuclear Summons: How to make the Nuclear Weapon States Negotiate Disarmament," Presentation at the Pugwash Workshop on "Eliminating Nuclear Weapons," New Delhi, March 1-3, 1998

- Participant, Meeting on "The Future of Russian-US Strategic Arms Reductions: START III and Beyond," Jointly sponsored by The Center for Arms Control, Energy, and Environmental Studies, The Moscow Institute of Physics and Technology, and The MIT Security Studies Program, Cambridge, USA, February 2-6, 1998

- "Modelling Prithvi and Agni," Presentation at the 9th International Summer Symposium on Science and World Affairs, Cornell University, Ithaca, USA, July 24 -August 3, 1997

- Participant, Conference on "The Future of Nuclear Weapons : A US-India Dialogue," Center for Advanced Study of India, University of Pennsylvania, May 5-8, 1997

- "Nuclear Energy in India: Problems and Prospects," Presentation at the NGO sessions of the NPT Preparatory Conference, United Nations, New York, USA, April 15, 1997

- "The Effects of Nuclear Explosions - a Case Study of Mumbai," Presentation at the Regional Meeting of the International Physicians for the Prevention of Nuclear War, New Delhi, India, February 21-23, 1997

- "History of the Comprehensive Test Ban Treaty," Overview Presentation at Panel Discussion on South Asia and the CTBT, Massachusetts Institute of Technology, USA, September 24, 1997

- "India's Participation in a Fissile Material Production Cutoff Convention," Presentation at the 8th International Summer Symposium on Science and World Affairs, Beijing, China, July 23-31, 1996

- "India's Participation in a Fissile Material Production Cutoff Convention" Presentation at the 10th Annual SSRC-MacArthur Foundation Fellows' Conference, Oxford University, United Kingdom, May 18-23, 1996

- "New Flavor Physics in b Decays," Presentation at the 2nd Workshop on High Energy Physics Phenomenology, SN Bose Institute, Calcutta, January 1996

- "A New Physics Source of Hard Gluons in Top Quark Production," Presentation at the 17th Annual MRST Meeting on High Energy Physics, Rochester, NY, USA, May 8-9, 1995

- Participant, Theoretical Advanced Study Institute in Elementary Particle Physics, Boulder, Colorado, USA, June 2-28, 1991

INVITED SEMINARS AND LECTURES

- "Life Under the Shadow: Twenty years of Nuclear Weapons in India and Pakistan," Seminar, Centre For India And South Asia Research, University Of British Columbia, March 29, 2018
- "Global Environmental Crises," Lecture in Course on Introduction to International and Intercultural Studies, Douglas College, March 26, 2018
- "The Fukushima Accident, Policy Choices and the Contested Future of Nuclear Energy," Lecture in Course on Urban Systems and Society, School of Community and Regional Planning, University Of British Columbia, March 12, 2018
- "Can Nuclear Energy be a Solution to Climate Change? Possible? Desirable? Feasible?," Colloquium, Indiana University of Pennsylvania, February 22, 2018
- "Nuclear energy, radioactive waste, and sustainability," Lecture in Course on Sustainability, Indiana University of Pennsylvania, February 22, 2018
- "The Nuclear Arms Race in South Asia: The Case of India," Lecture in Course on Weapons of Mass Destruction and International Security, Princeton University, Princeton, February 21, 2018
- "Nuclear Weapons in India: History and Risk," Seminar, Ethnic Studies Department & International Institute, University Of California, San Diego, November 30, 2017
- "Nuclear Power in the Middle East," Seminar, University of San Diego, November 30, 2017
- "Nuclear Energy and SMRs: Products and Problems," Lecture in Course on Nuclear Energy and Policy, Michigan State University, November 15, 2017
- "Nuclear Bombs and Nuclear Power: World Peace & Energy Security -- Unravelling the Promises," Asian College of Journalism, Chennai, India, November 6, 2017
- "Nuclear Energy and SMRs in Indonesia," Energy Studies Institute, National University of Singapore, October 25, 2017
- "The Global Future of Nuclear Energy," School of Public Policy and Global Affairs, University of British Columbia, Vancouver, October 18, 2017
- "The Nuclear Arsenals of India and Pakistan: Programmes, Plans and Dangers," Lecture in Course on Nuclear Weapons and Disarmament, University of Melbourne, May 8, 2017
- "The Nuclear Arms Race in South Asia: The Case of India," Lecture in Course on Weapons of Mass Destruction and International Security, Princeton University, Princeton, April 10, 2017
- "Why do States Build Nuclear Weapons? The Case of India," Carleton College, MN, November 4, 2016
- "Nuclear Power: Overview, Economics, and India," Carleton College, MN, November 4, 2016
- "Small Modular Reactors: An Inadequate Response to the Challenges Faced by Nuclear Power," Nanyang Technological University, Singapore, October 18, 2016
- "U.S. Launch of the World Nuclear Industry Status Report 2016," with Mycle Schneider, Natural Resources Defense Council, Washington, D.C., September 19, 2016
- "After Fukushima: Nuclear Power Programs Around the World," Google Hangout with Sigma Xi, October 11, 2016

- "Nuclear Weapons in South Asia: Programmes, Plans, and Dangers," Dr. Asghar Ali Engineer Memorial Advisory Committee and Coalition for Nuclear Disarmament and Peace, Mumbai, August 27, 2016

- "The Future of Nuclear Energy in India: Expectations and Constraints," School of Media and Cultural Studies, Tata Institute of Social Sciences, Mumbai, August 26, 2016

- "Understanding Nuclear Energy and Nuclear Diplomacy," Asian College of Journalism, Chennai, August 22, 2016

- "Whither Nuclear Power in the Middle East: The Cases of Saudi Arabia and Jordan," Nonproliferation Policy Education Center, Washington, D.C., May 5, 2016

- "Connections Between Nuclear Energy and Nuclear Weapons," Liu Institute for Global Issues, University of British Columbia, Vancouver, January 8, 2016

- "Exit, Voice, and Loyalty: Policy Choices and the Future of Nuclear Energy since Fukushima," Liu Institute for Global Issues, University of British Columbia, Vancouver, January 7, 2016

- "Nuclear Power and India's Energy Needs: Lessons from History," Energy Policy Institute at the University of Chicago- India Centre, New Delhi, December 23, 2015

- "Status of nuclear power in India and the potential impact of India- Japan nuclear cooperation," Citizens' Nuclear Information Center, Tokyo, November 6, 2015

- "Nuclear Energy in China and India: Can Ambitions Meet Reality?" Kyoto University, Kyoto, November 4, 2015

- "Assessing Risk Assessment: Nuclear Regulation and Reactor Safety," Princeton Institute for International and Regional Studies, Princeton University, Princeton, October 15, 2015

- "Nuclear Fission Energy: Status and Policies," ExxonMobil – Princeton University Workshop, Princeton, October 13, 2015

- "Nuclear India: Politics, Rhetoric and Reality," The Alliance for a Secular and Democratic South Asia & Science for the People, Massachusetts Institute of Technology, Cambridge, October 5, 2015

- "Challenges in Licensing Small Modular Reactors," Bapeten (Nuclear Energy Regulatory Agency of Indonesia), Jakarta, June 26, 2015

- "Reprocessing and Breeder Reactors in India," International Panel on Fissile Materials Panel on the Global Challenge of Reprocessing and Plutonium Disposal, NPT Review Conference, United Nations, New York, May 7, 2015

- "Nuclear Energy: Global Overview & the Case of India," Program on International Relations and Strategic Affairs, Princeton University & Center for Policy Research, Princeton, April 9, 2015

- "Atomic Development and Democratic Dissent: Opposition to the Koodankulam Nuclear Plant in India," Lecture, Program for South Asian Studies, Princeton University, Princeton, March 4, 2015

- "Nuclear Energy After Fukushima," Colloquium, Department of Physics, Ohio State University, February 23, 2015

- "Nuclear Energy in India: Current Status and Future Outlook," Korea Advanced Institute of Science and Technology, Daejeon, December 22, 2014

- "Nuclear Energy in India: Historical Record and Future Prospects," Institute of South Asian Studies, National University of Singapore, August 19, 2014

- "Nuclear Power in India: History and Prospects," Melbourne University, August 15, 2014
- "Motivations and Challenges for Small Modular Reactors," Nuclear Engineering Department, Universidade Federal do Rio de Janeiro, March 18, 2014
- "The Power of Promise: Examining the Feasibility of a Rapid Expansion of Nuclear Energy in India," South Asia Institute and the Kennedy School Project on Managing the Atom, Harvard University, Cambridge, December 6, 2013
- "Fukushima: Implications for the Understanding of Severe Accidents and the Future of Nuclear Energy," Colloquium, Department of Physics, Case Western University, Cleveland, November 21, 2013
- "Nuclear Energy: Issues in India and Around the World," Presentation at Prayas Energy Group, Pune, November 1, 2013
- "Challenges in Licensing Small Modular Reactors," Trilateral Meeting, University of Maryland, College Park, September 19-20, 2013
- "Nuclear Energy and Climate Change," Presentation at the Heinrich Böll Foundation, Beijing, August 6, 2013
- "Nuclear Power: Why, What, Why Not," Lecture, Vermont Law School, South Royalton, July 12, 2013
- "Nuclear Arms Race in South Asia: The Case of India," Lecture at the Heinrich Böll Foundation, Berlin, April 29, 2013
- "The Future of Nuclear Energy in India: History, Technology, and Economics," Program in South Asia Studies, Princeton University, Princeton, March 28, 2013
- "Nuclear Energy in India: History, Technology, and the Future," King's College London, March 20, 2013
- "The Potential for Severe Accidents Associated with Nuclear Power," Round Table on Liability Legislation in India, New Delhi, March 17, 2013 (over Skype)
- "Nuclear Energy in India: Learning from the Past, Thinking about the Future," Indian Institute of Technology, Madras, February 22, 2013
- "The Power of Promise," Jawaharlal Nehru University, New Delhi, February 20, 2013
- "Risk Perception in the Indian Nuclear Establishment," The Energy and Resources Institute (TERI), New Delhi, February 20, 2013
- "Nuclear Power: Motivations and Problems," National Institute of Immunology, New Delhi, February 19, 2013
- "Nuclear Energy in India: Perspectives on its Past, Present and Future," Madras Institute of Development Studies, Madras, February 18, 2013
- Is Nuclear Energy the Answer to India's energy needs? Loyola College, Madras, February 18, 2013
- "Nuclear Accidents and Learning: The Indian Experience," National Institute of Advanced Studies, Bangalore, February 15, 2013
- "Nuclear Energy in India: Past and Future," Indian Institute of Management, Bangalore, February 14, 2013

- "Nuclear Energy in India: Perspectives on its Past, Present and Future," Hyderabad Central University, Hyderabad, February 13, 2013

- "Nuclear Energy in India," Panel Discussion at Lamakaan: An Open Cultural Space, Hyderabad, February 12, 2013

- "Worried in Koodankulam: Nuclear Safety and Public Protests in India," Lecture at the San Jose Peace and Justice Center, San Jose, December 22, 2012

- "Organizing for Nuclear Disarmament and Peace in India," Hiroshima/Nagasaki Commemoration, Coalition for Peace Action, Princeton, August 6, 2012

- "Small Modular Reactors: Features, Motivations," Exploring the End of Nuclear Power and Examining its Proliferation and Health Problems, Institute for Energy and Environmental Research, Washington, D.C., July 25, 2012

- "Connections Between Nuclear Power and Nuclear Weapons: Production," Exploring the End of Nuclear Power and Examining its Proliferation and Health Problems, Institute for Energy and Environmental Research, Washington, D.C., July 25, 2012

- "Nuclear Power: Why, What, Why Not," Lecture, Vermont Law School, South Royalton, July 13, 2012

- "Small Modular Reactors: Overview," Seminar at the Brookhaven National Laboratory, Upton, New York, May 9, 2012

- "Nuclear Power After Fukushima," Colloquium, Department of Mathematical Sciences, Montclair State University, Montclair, New Jersey, November 30, 2011

- "The Future of Nuclear Power" Fall 2011 Maclean House Lecture Series, Sponsored by the Office of the Alumni Association, Princeton University, Princeton, October 6, 13, & 20, 2011

- "The Economics of Nuclear Power," Seminar at the Indian Institute of Science, Bangalore, August 29, 2011

- "Nuclear Power: Risk and Ethics," Lecture at Ashoka Trust in Ecology and Environment, Bangalore, August 29, 2011

- "United Kingdom," Presentation at panel discussion on "The Challenges of Spent Fuel Management: Experience and Lessons from Around the World" at the AAAS Center for Science, Technology and Security Policy, Washington D.C., June 3, 2011

- "Nuclear Power: Global Trends, Future Projections," Presentation at panel discussion on "The Jobs, Costs, and Security Landscape of a US Nuclear Expansion," Organized by Center for Earth, Energy, and Democracy, Institute for Agriculture and Trade Policy, Minneapolis, March 25, 2011

- "Implications of Fukushima for Nuclear Safety: A Preliminary Assessment," Presentation at panel discussion on "After the Earthquake: Japan's Nuclear Plant Crisis" at the Woodrow Wilson School for Public and International Affairs, Princeton University, March 24, 2011

- "Nuclear Energy and Climate Change," Plenary Lecture at the Conference on "Towards a Nuclear Weapon Free World" and the 10th Anniversary National Convention of the Coalition for Nuclear Disarmament and Peace, New Delhi, December 11, 2010

- "Nuclear Power: Current Trends, Future Projections, Developing Countries," Bulletin of the Atomic Scientists, Doomsday Clock Symposium, Washington, D. C., November 4, 2010

- "Looking up at the Apocalypse: Disarmament, Climate Change, and Justice," Panel Presentation at "For a Nuclear Free, Peaceful, Just, Sustainable World Conference", Riverside Church, New York City, May 1, 2010

- "India: Climate Debates, Energy Trends," Princeton Environmental Institute, Princeton University, February 5, 2010

- "Dealing with Climate Change: Equity, Justice, and Social Change," Climate Change Panel, Bulletin of the Atomic Scientists, Doomsday Clock Symposium, New York City, January 13, 2010

- "A Nuclear Powered Solution to Climate Change: Feasible? Desirable?," Environment Affairs Forum, Princeton University, November 24, 2009

- "India's Energy Future: How Much Can Nuclear Power Contribute?," Science, Technology, and Environmental Policy Seminar, Princeton University, September 28, 2009

- "Nuclear Energy in India: History and Future," Rotary Club, Bangalore, March 14, 2009

- "Kya Dam Hai? The Economics of Nuclear Power," Gujarat Vidyapeeth, December 8, 2008

- "Between Three Hard Places: India's Energy and Climate Change Policies," Seminar, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, October 14, 2008

- "Nuclear Power as a Solution to Climate Change?," Seminar, John F.Welch Technology Centre, General Electric Company, Bangalore, September 15, 2008

- "Economic Costs of Nuclear Power in India," Seminar, Indian Institute of Management, Bangalore, March 21, 2008

- "Can Nuclear Power Help with Climate Change? Lessons from the Experience in India and Elsewhere," Lecture for Postgraduate Certificate Course on Technology and Sustainable Development, Indian Institute of Technology, Madras, January 14, 2008

- "The Nuclear Deal and the Evolving Indo-US Relationship," Lecture for course on "Globalization", Swaraj Vidyapeeth, Bangalore, December 29, 2007

- "Indo-US Nuclear Deal," Talk to CONCERNS, Student Group, Indian Institute of Science, Bangalore, November 17, 2007

- "The US-India Nuclear 'Deal': Underlying Issues and Debates," Seminar, Institute for Social and Economic Change, Bangalore, November 15, 2007

- "Some Aspects of the US India Nuclear Deal," Seminar, Indian Statistical Institute, Bangalore, November 7, 2007

- "Nuclear Energy: Economic and Environmental Aspects," Lecture for course on "Approaching the Environment in India – New Theories and Methods in the Study of the Nature-Society Interface," Institute for Social and Economic Change, Bangalore, August 9, 2007

- "Implications of the US India Nuclear Deal," Presentation to the Citizens for Alternatives to Nuclear Energy, Bangalore, April 19, 2007

- "Breeder Reactors: Overview and Economics," Seminar, National Institute for Advanced Studies, Bangalore, November 29, 2006

- "An Overview of Nuclear Power in India," Presentation to the Greenpeace International Advisory Committee, Greenpeace, Bangalore, June 4, 2006

- "India: Prisoner of the Nuclear Dream," Special Energy and Environmental Policy Lecture, Center for Energy and Environmental Policy, University of Delaware, May 18, 2006
- "The US-India Nuclear Deal," Seminar, Science, Technology and Global Security Working Group, Program in Science, Technology and Society, Massachusetts Institute of Technology, May 12, 2006
- "Nuclear Power in India: Failed Past, Dubious Future," Seminar, Nonproliferation Policy Education Center, Washington, D.C., May 10, 2006
- "The US-India Nuclear Deal," Seminar, Center for International Security and Cooperation, Stanford University, May 1, 2006
- "The US-India Nuclear Deal," Joint Seminar with Zia Mian, South Asia Studies Committee, Princeton University, April 25, 2006
- "Nuclear Weapons in India: Glimpses from History" and "Atomic Energy in India", Two lectures at the National Law School of India University, Bangalore, April 1, 2006
- "South Asia: Under the Nuclear Shadow," Seminar, Liu Institute for Global Studies, University of British Columbia, Vancouver, Canada, November 23, 2005
- "Promises and Failures: The Story of Atomic Energy in India," Colloquium, Raman Research Institute, Bangalore, October 6, 2005
- "Nuclear Power: Plans, Prospects, and Constraints," Presentation to Greenpeace, Bangalore, August 24, 2005
- "Nuclear Power in India: Current Status, Future Prospects," Seminar, Centre for International Security and Cooperation, Stanford University, July 20, 2005
- "Ionizing Radiation and Health," Lecture, Bangalore Planetarium, May 27, 2005
- "Technology Choices and their Implications: the Case of Nuclear Energy in India," Lecture, Course on Technology and Policy in India, Indian Institute of Management, Bangalore, March 16, 2005
- "Economics of Nuclear Power in India," Seminar, Institute for Social and Economic Change, Bangalore, February 17, 2005
- "Nuclear Energy and Nuclear Weapons: Issues for an Informed Public Debate," Public Lecture, Organized by Society for Promoting Participative Ecosystem, Prayas, Centre for Environment Education, and others, Pune, January 12, 2005
- "Technology and Development: Nuclear Energy in India," Two lectures, Course on Technology and Sustainable Development, Indian Institute of Technology, Chennai, January 4, 2005
- "Future of Nuclear Power in India," Lunch Seminar, Program on Science and Global Security, Princeton University, October 1, 2004
- "Nuclear Power in India: An Overview," Seminar, Department of Chemical Engineering, Indian Institute of Science, Bangalore, August 19, 2004
- "Secrecy and India's Nuclear Establishment," Lecture, Alternate Law Forum, Bangalore, May 21, 2004
- "A Progressive Bomb?," Seminar, China Study Group, New York, January 31, 2004
- "An Estimate of India's Uranium Enrichment Capacity," Lunch Seminar, Program on Science and Global Security, Princeton University, August 6, 2003

- "Nuclear Power in India," Seminar, Center for Energy and Environmental Policy, University of Delaware, May 15, 2003
- "Steps Towards Operationalizing the Indian Nuclear Arsenal," Lunch Seminar, Program on Science and Global Security, Princeton University, January 22, 2003
- "Normal Accidents and Nuclear War," Lecture, Course on "Engineers in Society," New Jersey Institute of Technology, October 24, 2002
- "Deployment of Nuclear Weapons and Early Warning in South Asia," Technical Seminar, Security Studies Program, Massachusetts Institute of Technology, October 10, 2002
- "Beyond Missile Defense," Division of Natural Sciences and Mathematics Colloquium, Colgate University, April 19, 2002
- "Health Impacts from Uranium Mining in India," Presentation to ASHA, Princeton University, February 16, 2002
- "The Environmental and Health Impacts of the Nuclear Fuel Cycle," Seminar, Institute for Social and Economic Change, Bangalore, January 3, 2002
- "Uranium Mining and Health in India," Presentation to ASHA, Columbia University, November 4, 2001
- "Economics of Nuclear Power from Fast Breeder Reactors in India," Seminar, Indira Gandhi Institute for Development Research, August 20, 2001
- "Nuclear Power Economics in India: Fast Breeders vs. Heavy Water Reactors," Seminar, Center for Energy and Environmental Studies, Princeton University, July 10, 2001
- "Scientists and India's Nuclear Bomb," Seminar, Center for International Security and Cooperation, Stanford University, March 13, 2001
- "Scientists and India's Nuclear Bomb," Lecture, Yale Center for International and Area Studies, Yale University, October 26, 2000
- "Nuclear Weapons in South Asia: A Scientist's Perspective," Presentation to the Stanford India Association, Stanford University, June 29, 2000
- "Prisoners of the Nuclear Dream: India, Pakistan, and the Making of Nuclear Nations," Seminar, Program on Science, Technology and Society, Massachusetts Institute of Technology, February 19, 1999
- "Nuclear Energy and Weapons in South Asia," Seminar, Gettysburg College, January 29, 1998
- "The Effects of Nuclear Explosions - a Case Study of Mumbai," Seminar, School of International Studies, Jawaharlal Nehru University, New Delhi, February 24, 1997
- "Walking Technicolor Signatures at Hadron Colliders," Seminar, Center for Theoretical Studies, Indian Institute of Science, Bangalore, July 1992
- "Electroweak Symmetry Breaking, Walking Technicolor, and the SSC," Seminar, Department of Physics, University of Wuppertal, Germany, February 1992