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March 5, 2007

Chief, Rules and Directive Branch  
Division of Administrative Services  
Mailstop T-6D59  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

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RULES AND DIRECTIVES

Dear Chief, Rules and Directive Branch,

The enclosed National Press Club Conference statement by Dr. Arjun Makhijani, of the Institute for Energy and Environmental Research, Takoma Park, MD – and the Associated Press release by David Gram, covering the meeting that took place last week in Montpelier – have been, along with BEIR VII, the sources for the statements I make below. I quote from them to support my comments.

*Not up for consideration are issues ranging from the possibility and consequences of a terrorist attack on the plant – to the – wisdom of generating highly radioactive waste for an extra 20 years when the federal government has yet to open a site to dispose of it.*

The above directly concerns the incarceration of radioactive isotopes that create havoc in the biosphere. Only if hermetically isolated for tens of thousands of years will these unstable isotopes be eligible to rejoin the vastly more numerous stable elements of which oceans and earth crust are made or else the background radiation will be too much for most living things.

Other quotes from the article:

*Richard Emch, the NRC's environmental project manager for the Vermont Yankee review, repeatedly said the agency was looking for "new and significant information" relating to the safety of Vermont Yankee's electrical, mechanical and other systems, and environmental impacts, for example, to fish species in the Connecticut River.*

*Rep. Sarah Edwards, P-Brattleboro, said the failure of the federal government to come up with a long-promised site for high-level waste was a new development since Vermont Yankee was last up for license review in 1972. "Isn't this new and significant information?" she asked.*

*In an interview, NRC spokesman Neil Sheehan said if Vermont tried to block the license extension, it could risk litigation because federal law puts the NRC solely in charge of nuclear plant safety.*

From a statement by Arjun Makhijani on the *Report Science for the Vulnerable and the Campaign to Include Women, Children and Future Generations in Environmental Health Standards* National Press Conference, Washington, DC, 19 October, 2006 : *In 2005 the Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation (National Research Council of the National Academies) issued a report that concluded that women have a 52 percent greater chance than men of getting cancer*

Source Review Complete  
Template = ASM-013

E-RIS = ASM-03  
All = R. Emch (RLE)

*from radiation exposure. Seven years ago, the Environmental Protection Agency had reached similar conclusions. Yet, much radiation protection regulation is still stuck in the past – its “reference” person is a man.*

Please see the enclosed Makhijani statement and please review the detailed Institute for Energy and Environmental Research Science for Democratic Action (IEER SDA) newsletter. I gave up my only copy to Mr. Richard Emch, the NRC environmental project manager for the Vermont Yankee review, after the meeting with VT Legislators at the Pavilion Building in Montpelier, Vermont on Tuesday, February 27th. I have sent away for others to distribute at talks in the NorthEast Kingdom of Vermont and to attach to this comment.

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My specific concern for this comment period is as follows: The National Research Council of the National Academies report has highly pertinent information about the effect of low level ionizing radiation on women, embryos, fetuses, and children. This information is also found in the BEIR VII report (Biological Effects of Ionizing Radiation, 7<sup>th</sup> report, issued October 18<sup>th</sup>, 2006. This information was not given its due by those who wrote the SEIS draft report for the VY relicensing process.

The NRC mission, as Mr. Neil Sheehan and Mr. Emch said, is nuclear plant safety and security. Sheehan stipulated that the NRC has been given the last word by the Federal Government to decide what is safe and what is not safe in the area of nuclear safety. If so, the NRC should explain in the report why it can ignore the science that proves that:

1. Low level ionizing radiation – radiating over a long period of time in the area it lodges in body tissue – causes cancer and can alter DNA in eggs and embryos.
2. Women, embryos, fetuses, toddlers and children are more susceptible to radiation exposure in general. Among the culprits is the low level ionizing radiation from unstable radioactive isotopes such as Strontium 90 and Tritium that are ingested and lodge in the body, in teeth, near bone marrow that builds immunity, and finally near the nuclei of female eggs and embryos.

The following facts are also relevant:

1. The off-gassing of nuclear power plants, including the Vermont Yankee, contain these and other radioactive isotopes that fall on the grass, get into milk and plants that humans and other mammals consume. Humans in turn consume the meat from some of those mammals who consumed contaminated plants. We are at the top of the food chain in most incidences. Though low level radiation from isotopes is the worst form of cancer-causing agents, other types of radiation also weaken the mammal's immune system, more specifically the militias of T Cells that can help combat the effects of this ionizing radiation. Human mammals sit in front of computers, televisions, fly in planes, and handle and ingest immune system depleting chemicals. All, over time, affect immune systems. Humans thus become much more likely not to have the T cells needed to combat the effect of ingested-and-lodged, ionizing, radioactive isotopes from the off-gassing of nuclear power plants such as the Vermont Yankee.

2. The incidence of breast cancer has increased in the last decades to one in every eight women. It is not surprising that this statistic resonates with the more recent statistic that women are 52 percent more likely to contract cancer than men.
3. Those who are economically challenged cannot afford organic food and supplemental vitamins and minerals that can boost immune system T cells and control nascent formation of cancerous cells. This fact should be considered in the environmental justice evaluations that are done in NRC Environmental Impact Statements. I would strongly recommend that all economically challenged people -- especially women and children -- living in the shadow of nuclear facilities should receive free immune booster supplements and extra allowances for certified organic food and milk, free from chemicals and radioactive isotopes. This should be kept up until 12.5 years have past after the decommissioning that region's reactor.
4. The Vermont Yankee does not have state-of-the-art filters in its 300 foot high smoke stack. Even if it did have them, it would still not be able to filter out tritium, a short-lived (half life -- 12.5 years) isotope that lodges near the nucleus of cells and radiates the DNA inside. This has been shown to cause aberrations in the DNA that result in miscarriage, deformities and it may be responsible for breast cancer developing during the life of that embryo/fetus. I do not have the most recent IEER SDA issue that explains this. Please see Mr. Emch's copy
5. If tritium can be somehow precipitated out of the gasses before emission and disposed of appropriately, this must be done. I do not have the IEER SDA issue that talks about this. Please see Mr. Emch's copy. I have tried to Google this but without much success.

Before it is relicensed, the Vermont Yankee should replace its filters with the most modern technology possible and also find a way to take out the tritium and have it isolated from the environment for its half life of 12.5 years and then some. This is because of the recent discovery of its affinity for the nucleus of the cell where it is able to modify the DNA.

Before it is relicensed, the Vermont Yankee should change its regulation criteria from "Reference Man" to "Reference Woman-Embryo-Fetus-Toddler-Child."

In paragraphs 5 and 6, Makhijani shows that the Connecticut Yankee Atomic Power Company was able to conserve the Reference Man, the young White male, as the "basic underlying document governing the regulations". (Please see #11(FRG11)). The NRC permitted the CY Atomic Power Company to argue that a *white male, 20-30 should be the basis for calculation, and that their "regulations prohibit considering doses to children" despite the fact "the plain language of the regulation itself does not restrict the terms 'critical group,' 'individual', or 'human being' to mean any specific age, race, or gender.*

I take this to mean that the overall language of the fully written regulation uses non-specific words in talking about one person, people and groups of people but, when it comes to setting the regulation for the standard for acceptable levels of ionizing radiation, its template is age-race-gender specific. Pretty blatant segregation, one might contend. If it is to continue, the tax paying public deserves to hear a full explanation of NRC logic so they can decide whether or not this discrimination should prevail. This is

happening in a democratic country which is known world wide for hard-fought-for civil rights non-violent action victories.

Thank you for considering this comment and for doing all you can to allow as much transparency and independent oversight as needed to assure that the over 100 aging reactors seeking relicensing are safe to live down wind from and are secure from potentially highly-malignant elements such as terrorist attacks on the spent fuel.

Land has been lost to invaders. The U.S. DOE and the U.S. DOD have eliminated land from our nation for tens of thousands of years due to commercial and military development of nuclear power in one form or another. Let us make sure that swaths of Vermont, New Hampshire, Massachusetts and Connecticut land will not be added to those of Washington, Nevada, New Mexico, Idaho and Kentucky, and Rocky Flats, Co.

Sincerely,

*Eleanor I. Gavin*  
Eleanor I. Gavin  
RN, retired

For Volume 14 of Science for Democratic Action, IEER Publication - Feb., 2007  
Please go to  
[www.ieer.org/sda/files/14-4.pdf](http://www.ieer.org/sda/files/14-4.pdf).

See especially: Health Risks of Tritium Pg 1, 10, 11, + 12  
by Arjun Makhijani, Bruce Smith, and Michael C. Thorne

Pg 12, 2<sup>nd</sup> TP

"In addition, following revelations of tritium leaks from a nuclear power plant in Illinois, it has come to light that deliberate discharges and accidental leaks may be a more widespread concern at commercial nuclear power plants than previously suspected. Significantly, even in the midst of the scandal in the summer of 2006, the NRC did not yet fully understand all of the sources of the tritium entering the environment at the full extent of the leaks."

Then go back to pg 10: and read TP's under Deficiencies  
in the Regulations how tritiated water + organically

bound tritium can cross the placental barrier. gamma vs alpha vs beta emitting radionuclides.

I enclose the Health Risks of Tritium: the Case for Strengthened Standards article. Thank you! Ely.

# Science FOR Democratic Action

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## Healthy from the Start: Building a Better Basis for Environmental Health Standards— Starting with Radiation

BY ARJUN MAKHIJANI, BRICE SMITH AND MICHAEL C. THORNE<sup>1</sup>

The last half century has seen great progress in environmental health protection. As part of this progress there has been a growing awareness that the focus must be the protection of those most at risk. The protection of children, in particular, has grown significantly in prominence. In the United States for example, President Clinton in 1997 issued Executive Order 13045, Protection of Children From Environmental Health Risks and Safety Risks. This Executive Order was endorsed with amendments in 2003 by President Bush.

There has also been a great deal of progress in radiation protection. The International Commission on Radiological Protection (ICRP), the U.S. Environmental Protection Agency (EPA), and the Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation of the National Research Council of the U.S. National Academies of Science (known as the BEIR committee) have all made significant contributions by developing age-specific and sex-specific dose and risk factors. However, regulations have generally not kept pace with the overall trend in environmental health protection or with important developments in the scientific understanding of radiation risks.

In fact, as our knowledge has grown, the gaps in the regulatory framework have become more evident. For example, many U.S. regulations remain focused on estimating the dose received by a hypothetical

SEE **HEALTHY** ON PAGE 2, ENDNOTES, PAGE 7

Help strengthen radiation  
protection standards

\* see page 13 \*

### I N S I D E

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Radiation exposures in utero can lead to a heightened risk of cancer and other ill-health effects, yet most radiation protection standards still are based on "Reference Man," a hypothetical adult male.

## \* Health Risks of Tritium: The Case for Strengthened Standards

BY ARJUN MAKHIJANI, BRICE SMITH AND MICHAEL C. THORNE<sup>1</sup>

Part of the inspiration for IEER's project to reorient radiation standards to the protection of those most at risk came from a simple realization about the simplest radionuclide, tritium.

Tritium is a form of radioactive hydrogen with two neutrons in the nucleus. Ordinary hydrogen has no neutrons while deuterium, a stable isotope of hydrogen, has one neutron.

All three hydrogen isotopes behave almost the same chemically. Therefore tritium (T) can replace hydrogen to form tritiated water (i.e. HTO or T<sub>2</sub>O).<sup>2</sup> Tritium decays via the emission of a beta particle, and is thereby transformed into a stable isotope of helium (He-3). With a relatively short half-life of 12.3 years, tritium is highly radioactive. For example, one gram (approximately the weight of a quarter of a teaspoon of salt) of tritium in tritiated water will contaminate

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## TRITIUM

FROM PAGE 1

almost 500 billion gallons of water up to the current drinking water limit of 20,000 picocuries per liter set by the U.S. Environmental Protection Agency (EPA). One ounce of tritiated water (HTO) would contaminate the entire annual flow of the Savannah River above the present drinking water limit.<sup>3</sup>

In addition to forming tritiated water, tritium can also displace non-radioactive hydrogen in other types of chemicals. Tritium that is part of a carbon-tritium bond is difficult to remove and is therefore referred to as non-exchangeable organically bound tritium (OBT). Animal studies indicate that one to five percent of the tritiated water in mammals is incorporated into organic molecules inside the body.

From these observations, it is clear that tritiated water and organically bound tritium can cross the placental barrier. This tritium can then be incorporated into an embryo/fetus and irradiate rapidly dividing cells, thereby raising the risk of birth defects, early miscarriages, and other problems.<sup>4</sup> Tritium therefore provides an important case study for examining how radiation protection standards need to be changed in light of risks to those who are not adult men.

### Deficiencies in the regulations

The scientific models used to evaluate the adverse health impacts of tritium have a number of serious weaknesses. For example, the models assume tritiated water is uniformly distributed throughout the body. As a result, the EPA predicts that all organs, except for portions of the gastrointestinal tract, receive the same dose for a given intake of tritium. However, tissues with a high water

Low-energy beta particles, like those emitted by tritium, are often much more effective at causing harm than currently assumed by regulations.

content would be expected to receive a higher dose than tissues like bone or fat. Fetal tissues have higher water content than maternal ones. As a result, tritiated water is

Tritiated water and organically bound tritium can cross the placental barrier.

likely to be present in higher average concentrations in fetal tissues, and this is indicated by animal studies. Furthermore, if organically bound tritium becomes incorporated into DNA, it

does not uniformly irradiate the whole cell; it preferentially irradiates the nucleus. Hence, the risk of damage to the DNA and of adverse health effects (including cancer but not only cancer) is considerably greater than if the tritium expended its energy in the cytoplasm of the cell.

Finally, the models used to evaluate the dose received by the embryo in the first several weeks of pregnancy are seriously deficient. Current models assume that the dose to the embryo for the first eight weeks is the same as the dose received by the uterine wall. This is a reasonable assumption only for penetrating gamma rays. It does not apply to alpha-emitting radionuclides like uranium; nor does it apply very well to radionuclides like tritium that emit relatively low-energy beta particles.<sup>5</sup> This is because alpha particles and low-energy beta particles do not travel very far, and thus the damage they cause is more localized than that from gamma rays.

### Tritium's damage potential

A related concern is the fact that low-energy beta particles, like those emitted by tritium, are often much more effective at causing harm than currently assumed by regulations. The effectiveness of different kinds of radiation in causing damage is taken into account by the "relative biological effectiveness" (RBE) factor. Current standards generally assume that gamma rays, x-rays,

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**TABLE 1: INTEGRATED RELATIVE BIOLOGICAL EFFECTIVENESS OF TRITIATED WATER AND ORGANICALLY BOUND TRITIUM**

Age group	Form of tritium	5% Confidence limit	Median	95% Confidence limit
Adult	HTO	1.2	2.3	3.8
	OBT	2.3	5.0	11.6
Fetus (maternal ingestion during pregnancy)	HTO	2.1	4.4	8.1
	OBT	4.0	9.8	23.1

NOTE: HTO = tritiated water in which one atom of ordinary hydrogen has been replaced by an atom of tritium. OBT = organically bound tritium. The numbers in the columns for confidence intervals mean that the RBEs would be less than the cited number for the percent of times indicated by the confidence interval were a series of identical experiments to be performed.

SOURCE: Estimated from Harrison, Khurshid and Lambert 2002, Table 8. The Integrated RBEs were calculated by dividing the tritium doses shown in this paper by the dose conversion factor for tritiated water in the EPA's Federal Guidance Report 11.

## TRITIUM

FROM PAGE 10

and all beta particles have an RBE of one — that is, the damage caused is directly proportional to the amount of energy deposited in the tissue. Alpha particles, on the other hand, which deposit all their energy in a smaller number of cells or even entirely in one cell, are assigned an RBE of 20. That is, the standards assume an alpha particle will do 20 times more biological damage than a gamma ray that deposits the same amount of energy in the body.

As noted, the low energy of the tritium beta particle can result in the deposition of all the energy in a short distance, which could be particularly damaging if the tritium is in the DNA. This makes tritium's beta particles not unlike alpha particles in some situations. Therefore, the RBE of tritium should not be taken to be equal to one for all forms of tritium, nor for all age groups. To examine this question more closely, Harrison, Khurshid and Lambert published a study in 2002 examining the assumptions used in current models. The dose conversion factors for various age groups estimated from this paper indicate a RBE of both tritiated water and organically bound tritium higher than one (see Table 1 on opposite page).

This work highlights the importance of the chemical form of tritium and the age at exposure in determining the amount of damage done by tritium. For example, using the median estimates from the table, we find that the damage done to a fetus from organically bound tritium is more than four times that done to an adult from tritiated water and nearly ten times bigger than that assumed by current models.

### The importance of organically bound tritium

Organically bound tritium produces more serious health risks than tritiated water for the same amount of tritium intake for two main reasons.

First, the chemical form influences the likelihood of tritium being integrated into DNA or other biomolecules. Since tritium's low energy beta particles don't travel very far, there will be a big difference in the damage done by tritium located in the nucleus of the cell (where the DNA is located)

to that located in the cytoplasm. Organically bound tritium ingested through food, for example, is more likely to be incorporated into biomolecules than tritium ingested by drinking tritiated water.

The second reason OBT is more dangerous is that it is generally retained in the body longer than tritiated water. Human studies indicate that half of the tritiated water in the body is removed every 10 days, whereas

Estimates of the health risks from tritium that focus only on cancer likely underestimate its actual impacts.

removing half of the OBT present takes 21 to 76 days. For certain molecules with very slow turnover rates, this time can grow to 280 to 550 days. The longer retention times of OBT are a particular concern if the tritium is incorporated into tissues such as neurons (the main cells of the nervous system) or oocytes (immature egg cells). Considering that ova are formed once per lifetime, the effects of radiation on the reproductive system of female fetuses, and the possible effect on the children of females irradiated in the womb, could be significant.

A specific example where the importance of OBT is very clear is tritiated thymidine. Experiments indicate

Additional research is needed regarding the health impacts of tritium.

that tritiated thymidine, an organic compound that can be incorporated into DNA, causes over 1,000 times as much damage during certain stages of embryonic development in mice as is caused by the same concentration of tritiated water.

This large difference would not be the case for all forms of OBT, since thymidine is a DNA precursor. However, this example illustrates the critical importance of considering the specific chemical forms of tritium, notably organically bound forms.

A final concern regarding models relates to tritium that has replaced a hydrogen atom in DNA. Because helium-3 does not bond easily to carbon, the decay of this tritium atom creates a free helium ion that breaks away from the molecule. This can lead to a variety of effects, such as single-strand DNA breaks. Point mutations are also possible, in which tritium's conversion into helium can convert one of the four building blocks of DNA (cytosine) into a different building block (thymine). However, the current models expect the direct damage from the beta particles to be more significant than the damage caused by the creation of helium-3.

### Non-cancer effects

Beyond issues with cancer risk models, estimates of the health risks from tritium that focus only on cancer likely underestimate its actual impacts. The increased risks to pregnant women and the embryo/fetus include early miscarriages, malformations, and genetic defects. Risks can also be multi-generational given that a woman's ova are produced while she is in her mother's womb.

Much additional research is needed regarding the health impacts of tritium. For example, since we do not have a quantitative understanding of early pregnancy failure, it is currently impossible to make a quantitative assessment of that health risk. Further, the ICRP model of radiation dose in the early weeks of pregnancy is not relevant for tritium dose. In addition, the effects of *in utero* exposure to tritium combined with chemical toxins, such as endocrine disrupting chemicals, needs to be studied, as does the potential for neurological effects.

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## TRITIUM FROM PAGE 12

### Tritium in the environment

While tritium is naturally present in very small concentrations, the use of tritium in nuclear weapons and the creation of tritium by commercial nuclear power plants have resulted in specific areas of concern. For instance, the Savannah River is polluted with tritiated water mainly due to nuclear-weapons-related activities at the Savannah River Site.


In addition, following revelations of tritium leaks from a nuclear power plant in Illinois, it has come to light that deliberate discharges and accidental leaks may be a more widespread concern at commercial nuclear power plants than previously suspected. Significantly, even in the midst of the scandal in the summer of 2006, the Nuclear Regulatory Commission did not yet fully understand all of the sources of the tritium entering the environment or the full extent of the leaks.

### Conclusion

In light of the deficiencies in the current models and the variety of potential non-cancer health effects, a more protective limit for tritium than the one in current use may be needed. We have concluded that 400 picocuries per liter for surface water should be considered as an interim target limit for offsite surface water at all nuclear power plants and U.S. Department of Energy nuclear sites while a better understanding of the impacts of tritium is developed. This level is 50 times lower than the EPA's current drinking water limit and corresponds to a lifetime risk of a fatal cancer of about one in a million.<sup>6</sup>

Significantly, the Department of Energy has already agreed to an action level of 500 picocuries per liter for tritium in surface water in the clean up at Rocky Flats. This level corresponds to Colorado's standard for tritium in surface water. It is based on the dose conversion

factor for tritium in EPA's Federal Guidance Report 11 (FGR 11). If one uses the most recent guidance, FGR 13, the limit would be 400 picocuries per liter, which has been adopted by the state of California as its health goal. Both the Colorado and California levels are set using a one in a million lifetime risk of a fatal cancer, which is the goal of cleanup under the Superfund law, formally called the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA.

The case for tightening the tritium limits as a preventive measure is even more persuasive when one considers the higher RBE of tritium, its possible non-cancer health effects, its possible synergisms with chemical toxins, and its potential effects arising from exposure in utero at certain crucial times during pregnancy. 

- 1 Arjun Makhijani, Ph.D., is president of IEER. Brice Smith, Ph.D., is senior consultant to IEER and assistant professor of physics at SUNY-Cortland. Mike Thorne, Ph.D., is a private consultant and an expert on radiological protection and environmental transport of radionuclides. This article is based on chapter 7 of the report *Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk* (IEER, October 19, 2006), on the Web at [www.ieer.org/campaign/report.pdf](http://www.ieer.org/campaign/report.pdf). The report chapter was written by Dr. Makhijani and it is summarized here by Dr. Smith with input from Dr. Makhijani. References can be found in the report.
- 2 Tritium can also combine with deuterium (D) to form DTO. This is important in situations where heavy water (D<sub>2</sub>O) is used in nuclear reactors, such as in Canadian nuclear power reactors or the plutonium production reactors in the United States at the Savannah River Site. The latter are now closed.
- 3 Assuming an average flow rate of 10,000 cubic feet per second (Makhijani and Boyd, *Nuclear Dumps by the Riverside: Threats to the Savannah River From Radioactive Contamination at the Savannah River Site (SRS)*, 2004, p. 18. On the Web at [www.ieer.org/reports/srs/index.html](http://www.ieer.org/reports/srs/index.html).)
- 4 Unless otherwise specified, the forms of tritium discussed in this article are either tritiated water or OBT.
- 5 A typical beta particle emitted from tritium has 35 times less energy than a typical beta particle emitted by strontium-90.
- 6 Calculated from dose conversion factors at various ages in FGR 13 compact disk (EPA 2002), approximate variations in water consumption with age, and an average cancer fatality risk factor of 0.057 cancers per sievert.

## ANSWERS TO ATOMIC PUZZLER SDA 14-3 CALCULATING THE EMISSIONS FROM A COAL FIRED PLANT

1.  $22,880,000 \text{ Btu per metric ton} \times 0.001 \text{ ton per kilogram} \times 1055 \text{ joules per Btu} = 24,140,000 \text{ joules per kilogram} = 2.414 \times 10^7 \text{ joules per kilogram}$
2.  $1 \text{ kilowatt-hour} = 1,000 \text{ joules per second per kilowatt} \times 3600 \text{ seconds per hour} = 3,600,000 \text{ joules per kilowatt-hour} = 3.6 \times 10^6 \text{ joules per kilowatt-hour}$
3.  $2.414 \times 10^7 \text{ joules of heat energy per kilogram} / 3.6 \times 10^6 \text{ joules per kilowatt-hour} = 6.704 \text{ kilowatt-hours (thermal) per kilogram}$
4.  $6.70 \text{ kilowatt-hours (thermal)} \times 0.34 = 2.28 \text{ kilowatt-hours (electrical) per kilogram of coal} \rightarrow 1/2.28 = 0.439 \text{ kilograms of coal per kilowatt-hour of electricity}$
5.  $0.439 \text{ kilograms of coal per kilowatt-hour of electricity} \times 0.61 \text{ kilograms carbon per kilograms of coal} = 0.268 \text{ kilograms of carbon per kilowatt-hour of electricity}$
6.  $0.268 \text{ kilograms of carbon per kilowatt-hour of electricity} \times 3.67 \text{ kilograms of CO}_2 \text{ per kilogram of carbon} = 0.982 \text{ kilograms of CO}_2 \text{ per kilowatt-hour of electricity}$



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**Statement of Arjun Makhijani on the Report *Science for the Vulnerable* and the Campaign to Include Women, Children, and Future Generations in Environmental Health Standards**  
National Press Club Press Conference, Washington, D.C.

19 October 2006

In 2005, the Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation (National Research Council of the National Academies) issued a report that concluded that women have a 52 percent greater chance than men of getting cancer from radiation exposure. Seven years ago, the Environmental Protection Agency had reached similar conclusions. Yet, much radiation protection regulation is still stuck in the past – its “reference” person is a man.

Consider RESRAD, the government’s software for calculating radiation doses from residual radioactivity in the soil. It is used for setting maximum limits for residual radioactivity as part of the decommissioning of radioactively contaminated sites, including the sites in the Department of Energy’s nuclear weapons complex. Hundreds of billions will have been spent before the remediation is complete. RESRAD is very useful, but it has one major problem: its computations of radiation dose are based on “Reference Man,” defined as a young adult, “Caucasian” male, who is “Western European or North American in habitat and custom.” That is the definition generally used for “Reference Man.”

It is clear that a central principle of environmental health protection – *protecting those most at risk* – is missing from much of the U.S. regulatory framework for radiation. For instance, women’s higher cancer risk per unit of radiation exposure is not properly reflected in current regulations. Neither is the possibility of early miscarriages or fetal malformations potentially caused by radiation exposure.

Radiation standards generally specify a maximum allowable dose or a maximum contaminant limit, but these are derived numbers based on an underlying notion of maximum fatal cancer risk that any individual in the exposed population would suffer. The use of Reference Man to derive the dose limit means that the cancer risk for women would be considerably higher than that claimed as the maximum target value in the regulation. It also means that the diet of many Native Americans, such as the Yakima in Washington state, or of African Americans along the Savannah River in Georgia and South Carolina, that relies much more on fishing than considered normal for a White “Reference Man.” would not be taken into account in radiation protection.

Contrary to Executive Order 13045, *Protection of Children From Environmental Health Risks and Safety Risks*, signed by President Clinton in 1997 and endorsed with amendments in 2003 by President Bush, agencies of the government allow corporations to ignore children. Consider, for instance, a remarkable official opinion from the Nuclear Regulatory Commission to Connecticut Yankee Atomic Power Company [CY], written in 2001, that allowed the company to argue that a “white male, age 20-30” should be the basis for its calculations. And it explicitly allowed the company to argue that “our regulations *prohibit*

considering doses to children” despite the fact “the plain language of the regulation itself does not restrict the terms ‘critical group,’ ‘individual,’ or ‘human being’ to mean any specific age, race, or gender.”<sup>1</sup>

The NRC permitted Connecticut Yankee to argue along these lines because the basic underlying document governing the regulations is the EPA’s Federal Regulatory Guidance report number 11 (FRG 11), which is based on Reference Man, the young White male. We believe that the inclusion of children in radiation protection should not be optional.

Finally, the embryo/fetus, which is, in many ways, the most sensitive to radiation in terms of *non-cancer* health risks, is excluded from the regulatory scheme, except for protection of pregnant women in radiation-controlled work places after a voluntary declaration of pregnancy. Even there, the maximum allowable dose to the embryo/fetus, 500 millirem, is five times greater than best practices in Europe, for instance, in Germany. Also unlike Germany, there is no U.S. requirement to protect breastfeeding women from contact with significant radioactive contamination in the workplace after she declares that she is breastfeeding.

There is a need to consider the specific non-cancer health risks posed by certain radionuclides, both because of their nature and their widespread prevalence in the nuclear industry. Tritium, which is discharged into waterways in the form of radioactive water, including sources drinking water, from nuclear power plants and some nuclear weapons plants, crosses the placenta. It may increase the risk of early failed pregnancies or malformations. Similarly, strontium-90, concentrates in the red bone marrow, which is the source of stem cells for the immune system. Therefore, harm at the stage of rapid development of fetal and children’s bones may create the potential for a wide variety of health problems. Such non-cancer effects are not well-understood, especially at low radiation doses; much less are they the concern of radiation protection regulations. Laboratory experiments, many done at the Armed Forces Radiobiology Research Institute, indicate that uranium, including depleted uranium, may be neurotoxic and may cross the placenta. It may act in the body like lead, but with the harm compounded by radioactivity. While these effects have not been confirmed at low levels of exposure, there is significant cause for concern and reason for the exercise of precaution in regulation. It would be tragic, if, having the knowledge that we do, radiation protection regulations allowed the potential problem to grow, as society did with lead in gasoline for decades.

In sum, while much progress has been made in radiation protection since the late 1950s, there are still vast gaps, many of which go back to the use of Reference Man. It is time to retire him. Others are related to the lack of consideration to non-cancer health effects.

Finally, estimation of health risk, as expressed in regulations, is generally confined to assessment of one chemical at a time or to radiation. Combined radiation and chemical exposures are rarely considered in research and are absent from regulatory framework. This is partly because research into combined effects is difficult, but it is also because the regulatory concepts used in the two fields are somewhat different.

The report we are making public today, *Science for the Vulnerable*, is designed to provide the scientific foundation for a broader and deeper consideration of how environmental health standards should be set. The coalition we are forming today will educate the public at large regarding the variety of environmental health risks we face and how they may be reduced. Among other things, we are asking President Bush to issue an Executive Order for executive branch agencies to review their definitions of reference persons and change them as needed to protect those most at risk.

Our initial list of signatories includes people from many backgrounds and a large variety of organizations, from public health to religious to Native American, to environmental to academic to elected officials to mothers concerned about the safety of breast milk. I sent the letter to President Bush yesterday, on behalf of the signatories. We are hopeful that President Bush will give the matter of strengthening the framework of environmental health protection his attention with the speed it deserves.

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<sup>1</sup> NRC 2001 p. 372 and p. 374, emphasis added. See *Science for the Vulnerable*, at [www.ieer.org](http://www.ieer.org), p. 98 for the full citation.



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**New National Campaign Launched to Strengthen  
Radiation, Chemical Exposure Health Protection Standards  
Groups Ask President Bush to Shift Basis of Federal Regulations  
from Adult Males to Groups Most At Risk – Pregnant Women, Children**

*Washington, D.C., October 19, 2006:* A broad coalition of scientists, physicians, cancer prevention leaders, children's health organizations, environmental justice advocates, and women's groups today launched a national campaign to shift the basis of many U.S. radiation health protection standards from an adult "Caucasian" male model, called "Reference Man," to those most at risk, specifically including children and pregnant women..

The coalition is urging President Bush to direct all federal agencies – including the Department of Energy, the Nuclear Regulatory Commission, the Environmental Protection Agency, and the Food and Drug Administration – to review their exposure standards. A new report, produced by the Institute for Energy and Environmental Research (IEER), *Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk*, forms the scientific basis of the campaign.

Many federal radiation protection standards, such as limits on how much residual radiation will be allowed in contaminated soil, are based on "Reference Man," a hypothetical adult "Caucasian" male who is 20 to 30 years old, weighs 154 pounds, is five feet seven inches tall, and is "Western European or North American in habitat and custom." However, other groups, including women, children, and the embryo/fetus, are often more sensitive to the harmful effects of radiation or toxic materials.

"A central principle of environmental health protection – protecting those most at risk – is missing from much of the U.S. regulatory framework for radiation," said Arjun Makhijani, Ph.D., president of IEER and co-author of the report. "Women's higher cancer risk per unit of radiation exposure is not properly reflected in current regulations. Neither is the possibility of early miscarriages or fetal malformations potentially caused by radiation exposure."

The report contains a detailed discussion of the higher risks to women, and especially to female children, of certain kinds of cancer, notably thyroid cancer. A female infant drinking contaminated milk is a hundred times more at risk of thyroid cancer than an adult male, according to the report. For the same amount of radiation dose, women have a 52% greater chance of getting cancer. It also notes that water made radioactive with tritium crosses the placenta and affects the developing embryo/fetus, and can cause early failed pregnancies as well as malformations. These health risks are not part of regulatory considerations currently despite the fact that tritium discharges are occurring from both nuclear power plants and some nuclear weapons facilities, such as the Savannah River Site.

"A considerable and growing body of evidence indicates that exposure to radiation and synthetic chemicals is contributing to increasing rates of breast cancer in the U.S. and other industrialized countries," said Jeanne Rizzo, R.N., executive director of the Breast Cancer Fund. "If we change our safety standards to specifically protect women and girls, we will spend less time, money and heartache treating diseases caused by environmental exposures."

The report provides a model for assessing some of the simpler combined effects of chemicals and radiation, including when they reinforce one another. "It is important to consider how radiation and chemicals can act together to promote cancer," said Dr. Michael Thorne, a British consultant to IEER, and a co-author of the report. "Exposure to ionizing radiation could increase the number of cells that have the potential to proliferate to form breast cancers later in life and exposure to chemicals that modify estrogen levels could preferentially enhance the survival of such cells."

"Rapidly increasing rates of cancers and other illnesses related to radiation and hazardous toxic chemicals in our environment are creating a population of grandparent-less families in our environmental justice communities," said LaDonna Williams, Executive Director of People for Children's Health & Environmental Justice. "The federal government must act now by adopting more protective standards to reverse this negative trend that is having devastating impacts on our families, health, lives and environment."

"I've never known a woman to give birth to a full-grown, 154-pound 'Reference Man'," observed Mary Brune, Co-founder of MOMS, Making Our Milk Safe. "Pregnant women, developing children, and infants require and deserve a higher degree of protection than the current regulatory framework provides. The IEER report provides realistic and inclusive guidelines for protecting the most vulnerable among us."

The report points out that the concepts to solve much of the problem already exist in the form of the "maximally exposed individual" and of the "critical group" but have not been widely applied. The government's model for setting residual radioactivity standards for cleaning up radioactively contaminated sites, RESRAD, depicts a family on the front panel display, but its standard model converts contamination to radiation dose only for "Reference Man." In the context of clean-up of Department of Energy sites, the risk to a pregnant woman farmer, the fetus, and her children should be evaluated, rather than only Reference Man. *The most sensitive should be protected.*

The report makes specific recommendations regarding strengthening workplace protections. Besides abandoning "Reference Man" and replacing him with the most vulnerable population subgroup, the report makes specific recommendations regarding workplace protection for the embryo/fetus. The U.S. standard for workplace radiation exposure is five times more lax than that in Germany, for instance. The maximum exposure should be lowered to 100 millirem per year, from the present 500. The report also recommends that the United States adopt a rule for radiation controlled workplaces to protect women from bodily contamination, once women inform their employers that they are breastfeeding. Unlike Europe, no such protection exists in the United States today.

In view of the potential non-cancer health risks of tritium to the embryo/fetus and pregnant women, which are absent from the framework of present radiation protection or drinking water regulations, the report recommends consideration of restricting discharges so that offsite surface water has no more than 500 picocuries per liter of tritium, which is a standard that has already been adopted by the State of Colorado for the environs of the Rocky Flats Plant, near Denver. The U.S. Department of Energy agreed to this limit as a site-specific standard in the clean-up of Rocky Flats, which has now been decommissioned. The present national drinking water maximum contaminant limit for tritium is 20,000 picocuries per liter. The report recommends an analysis to determine the feasibility of a limit of 500 picocuries per liter at all nuclear power and nuclear weapon sites, including remediation of those sites.

The IEER report and other documentation, including statements, the full definition of "Reference Man," and the Presidential Executive Order issued by President Clinton in 1997 and extended by President Bush in 2003 on protecting children from environmental health risks, are available online at [www.ieer.org](http://www.ieer.org).

Also please see [www.icer.org/campaign/letter.php](http://www.icer.org/campaign/letter.php)  
"Open Letter to President Bush on Protecting the Most Vulnerable"  
(or google Icer National Press Club Oct. 19, 2006)

## NRC gets earful from lawmakers on Vermont Yankee license renewal

By David Gram, Associated Press Writer | February 27, 2007

MONTPELIER, Vt. —Vermont lawmakers asked pointed questions and voiced strong criticism Tuesday in a meeting with regulators reviewing Vermont Yankee's request for a 20-year license extension.

The legislators, mostly from Windham County where the plant is located, voiced frustration that the U.S. Nuclear Regulatory Commission license renewal process is limited to making sure components at the 35-year-old Vernon reactor can withstand 20 years of operation beyond the plant's scheduled 2012 license expiration, and the environmental impacts of that continued operation.

Not up for consideration are issues ranging from the possibility and consequences of a terrorist attack on the plant to the wisdom of generating highly radioactive waste for an extra 20 years when the federal government has yet to open a site to dispose of it.

"We've had promises for years from the federal government that we were going to have a site of permanent storage (of high-level waste)," said state Rep. Virginia Milkey, D-Brattleboro, "and I think that date has gone by."

Richard Emch, the NRC's environmental project manager for the Vermont Yankee review, repeatedly said the agency was looking for "new and significant information" relating to the safety of Vermont Yankee's electrical, mechanical and other systems, and environmental impacts, for example, to fish species in the Connecticut River.

Rep. Sarah Edwards, P-Brattleboro, said the failure of the federal government to come up with a long-promised site for high-level waste was a new development since Vermont Yankee was last up for license review in 1972. "Isn't this new and significant information?" she asked.

Vermont passed a law last year giving the Legislature veto power over relicensing Vermont Yankee; it must decide by July 2008. The law spells out a process that is to include three public hearings.

It's unclear what would happen if the NRC approves the license extension — officials said it had approved about 50 at plants around the country and denied none — and Vermont decides against it.

In an interview, NRC spokesman Neil Sheehan said if Vermont tried to block the license extension, it could risk litigation because federal law puts the NRC solely in charge of nuclear plant safety.

In another development, an NRC panel has ruled that Vermont Yankee doesn't need test its ability to shut down from full power despite a 20 percent increase in output.

Monday's ruling from the NRC's Atomic Safety and Licensing Board rejected a formal contention about the power boost brought by the nuclear watchdog group New England Coalition. It ends the last outstanding bit of regulatory business connected with the increase, which Vermont Yankee completed last spring.

The coalition cited recommendations from NRC staff that as a general rule, plants contemplating such an increase in power output conduct one or both of two types of reactor "scram" — or immediate shutdown — from full power.

The NRC panel said Vermont Yankee owner Entergy Nuclear had provided enough information based on experience at other nuclear plants around the country to avoid the need for either type of test at the Vernon reactor.