2006 3-Day Science Teacher Workshop
"Science of Nuclear Energy and Radiation"
July 19 – 22, 2006 Richmond, VA

Final Report

1. Introduction

The Virginia local sections of the American Nuclear Society (VA-ANS), the Health Physics Society (VA-HPS), and the North American Young Generation in Nuclear (VA-NAYGN) combined forces and volunteers to organize the first annual three-day science teacher workshop (3D-STW) on July 19-22, 2006 in Richmond, VA. The workshop, titled "Science of nuclear energy and radiation", was hosted by the Virginia Commonwealth University's (VCU) School of Engineering. Technical tours were held at VCU Health System's Nuclear Medicine facilities and at Dominion's North Anna Power Station. In addition, a special social event was held at the Science Museum of Virginia. The website http://local.ans.org/virginia/3dSTW/ was created and contained at all times the most up-to-date information about the workshop, including the on-line registration, the workshop assignments and the on-line final exam.

A weeklong science teacher's workshop was organized by the University of Virginia from the early 1980's until the shutdown of their nuclear reactor in 1997. Since 1998, VA-ANS and VA-HPS have jointly organized a very successful one-day science teacher's workshop once a year at different locations throughout Virginia. However, attendees had expressed a desire for more breath and depth than possible in one day, which was the impetus behind this new three-day workshop. This workshop's mission was to educate the science teachers in attendance and their students via the teachers, about the concepts and beneficial applications of nuclear energy and radiation. The intent was to present only factual information, based on scientific data and knowledge.

The more teachers learn about nuclear science and technology, the more students will be exposed to these topics. Informed teachers and students will transfer this information to their families and members of the public, which will enable them to have a better understanding of these topics and be more capable of making informed decisions when discussing applications of nuclear energy and radiation in their daily lives.

Fifty teachers registered and paid to attend the workshop. Forty-five teachers attended the workshop, from Virginia, Idaho, Minnesota, New Jersey, Pennsylvania, and Texas. The teachers taught at the elementary, middle and high school levels in the following areas: Science, Physics, Astronomy, Engineering, Chemistry, Biology, Life Science, Earth Science, Environmental Science, and Mathematics.

Figure 1 – Registration Desk

2. Sponsorship

One of the goals of the organizers was to be able to offer the three-day workshop at a very low cost for the teachers, since many of them might have to pay out-of-pocket for their training. Thanks to the monetary support of many corporate and individual sponsors, it was possible to obtain the $14,619 budgeted for the workshop. These funds provided the lodging, all the meals, all educational materials, a Geiger-Mueller meter and the CEUs essentially for free to all the attendees to the 2006's science teacher's workshop (a token registration fee of $50 was required to provide some assurance of attendance).

In addition to monetary support, some sponsors provided in-kind support by allowing their employees to devote some time and company resources to the planning and organization of the workshop, or to the refurbishment of the Geiger-Mueller meters.

Finally, several volunteers kindly donated their vacation time to support the 3D-STW.

The 2006 Three-Day Science Teacher's Workshop sponsors include:

* The Atlantic Group
* Bechtel
* Central Virginia Community College
* General Electric
* BWX Technologies, Inc.
* Excel Services, Inc.
* The Virginia Section of the American Nuclear Society
* AREVA
* Maracor Software & Engineering, Inc.
* Master-Lee
* Westinghouse
* Dominion
* Global Dosimetry Solutions
* Dan Laslie
* Joe Montague
* Panera Bread
* Richmond Joint Engineers' Council
* Jefferson Laboratory
* The American Nuclear Society
* NASA
* RadioShack

3. Staff & Instructors

The lead organizer for this workshop was Sophie Gutner of Dominion. The logistics lead was Rebecca Kepler of Dominion. The technical program lead was W. Reed Johnson, a retired UVA professor, and the assistant technical program lead and registration lead was Sama Bilbao y León of Dominion. Many other volunteers helped in various roles throughout the year preceding the workshop.

A group of volunteers, top experts in their own fields, was recruited to be the instructors and lecturers for the workshop's lectures and laboratories. The organizer's philosophy was that the instructors did not need to be professional communicators, but they had to be experts in the areas that they were to present. However, practice sessions were scheduled for most presenters to fine tune their talks, ensure consistency and continuity with other lectures, and improve their presentation skills.

4. Educational Materials

Thanks mainly to the ANS-PI grant awarded by the ANS Outreach Department, a variety of informational materials were provided to the teachers, including the following:

* Binder and CD-Rom containing the lecture material and additional, supporting articles
* "Understanding radioactive waste" (ISBN 1-57477-135-3)
* "Bluebells and nuclear energy" (ISBN 0-944838-63-4)
* "Nuclear power: villain or victim?" (ISBN 0-9658096-0-9)
* "Radiation and modern life" (ISBN 1-59102-250-9)
* "Energy education resources" (published by the Department Of Energy)
* North Anna and Surry Power Stations information

* VCU School of Engineering, BWX Technologies, NASA, and Science Museum of Virginia information
* A 1-to-1 scale fuel pellet
* A Geiger-Muller survey meter and lantern mantle
* Flyers and brochures:
    - The Greening of the Nuclear Age
    - For a career that is Rewarding, Challenging, Exciting...
    - Nuclear science & technology: crucial to sustainable development
    - Nuclear power: a sustainable source of energy
    - The food irradiation process
    - The facts about food irradiation
    - Nuclear energy facts: questions & answers
    - Nuclear energy: powering america's future
    - Nuclear related websites
    - Estimate your personal radiation dose
    - Nuclear power plant EP: protecting our neighbors in the event of an emergency
    - www.aboutnuclear.org
    - A day with atom... living with zest!
    - Health Physics Society flyer
    - Career opportunities: careers plentiful for nuclear grads
    - Medical news: nuclear medicine helps patients avoid pain
    - We're all naturally radioactive (packet)

Figure 2 – Educational Materials

5. Program

The organizers did not have to start from scratch to prepare the curriculum because some of the current active members were also active during the 1980s and early 1990s. W. Reed Johnson had organized the weeklong workshops at the University of Virginia. Now retired, he was able to provide guidance and advice for the new workshop. The complete workshop program is provided in Attachment 1. It is an intense, three-day course that covers a broad spectrum of subjects related to nuclear technology. Nuclear power is fairly central, but other topics, such as food irradiation, waste management, and nuclear medicine, are intentionally included to provide breadth and perspective. Whereas a one-day workshop can only cover the basics, three days allow enough time to provide a much richer view of nuclear science and technology.

In addition to the actual instruction time, both instructors and volunteers were encouraged to spend time with the participants. The organizers considered that putting a human face to "nuclear" and that establishing the foundation of a longer-term relationship with the teachers was a key element of the workshop. It was important that the teachers saw the organizers as normal people, concerned about their families, their communities and the environment, and, in particular, as top professionals who know their jobs and care deeply about doing them well.

5.1. Pre-Workshop Homework Assignment

As part of the curriculum, the attendees were required to prepare and submit a pre-workshop homework assignment, which involved the following:

* Read the article "A future for nuclear power in Virginia" by Richard M. Roberds (Virginia Issues and Answers, Fall 2004), http://www.via.vt.edu/fall04/feature4.pdf
* Prepare and submit a short summary describing the future role of nuclear energy in Virginia (or in another state if the teacher doesn't live in Virginia), based on the Roberds article and the teacher's own personal opinion.
* Find a recent news piece on nuclear power or radiation (newspaper, magazine, scientific journal, etc); prepare and submit a short summary.
* Provide three questions or issues that the teacher would like to get answered/discussed during the workshop.

The intent of this assignment was to help the teachers get ready and develop a questioning attitude in preparation for the workshop, and to assist the program leads customize the materials covered in the workshop lectures and discussion sessions and ensure that all relevant topics and issues were discussed.

A summary of the teachers' questions is provided in Attachment 2.

5.2 Lectures

The following topics were covered in lecture format:

* "Radiation and nuclear energy basics" by Keith Welch (Jefferson Lab)
* "Biological Effects of Radiation" by Beth Hilt (Dominion)
* "Beneficial uses of Nuclear Science and Technology" by Sama Bilbao y León (Dominion)
* "Nuclear Medicine" by Mark Crosthwaite (VCU Nuclear Medicine Technology)
* "Nuclear Power Fundamentals" by Todd Flowers (Dominion)
* "Reactor Safety" by Ross Anderson (Dominion)
* "The Nuclear Fuel Cycle: Mining, Enrichment and Fuel Fabrication" by Joe Montague (Dominion)
* "The Nuclear Fuel Cycle: Used Nuclear Fuel Management (Yucca Mountain, Utah, Reprocessing, etc) by Kevin McCoy (AREVA)
* "The Future of Nuclear: New Nuclear Plant Construction, Nuclear Economics and the Hydrogen Economy" by Marvin Smith (Dominion)

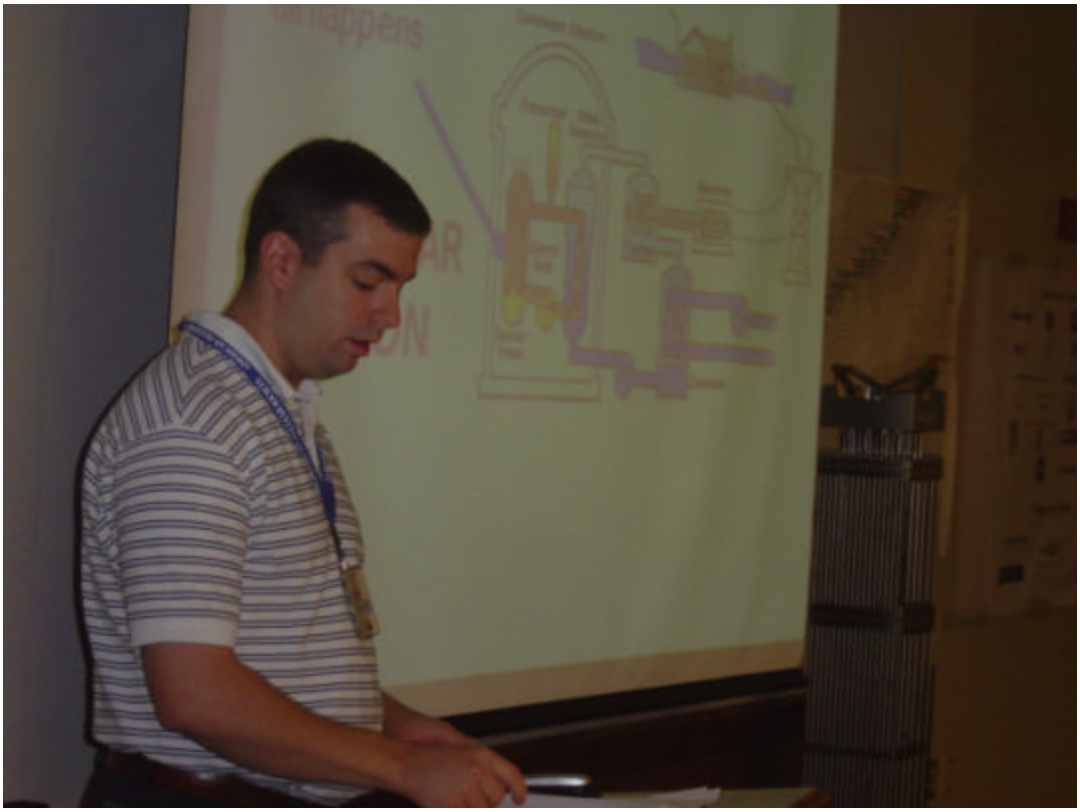


Figure 3 – Todd Flowers' "Nuclear Power Fundamentals" Lecture

5.3 Labs/Demonstrations

The following hands-on activities were offered:

"Geiger meter survey, its care and use in the classroom" by W. Reed Johnson

Figure 4 – Teachers learning to use their Geiger-Muller survey meter

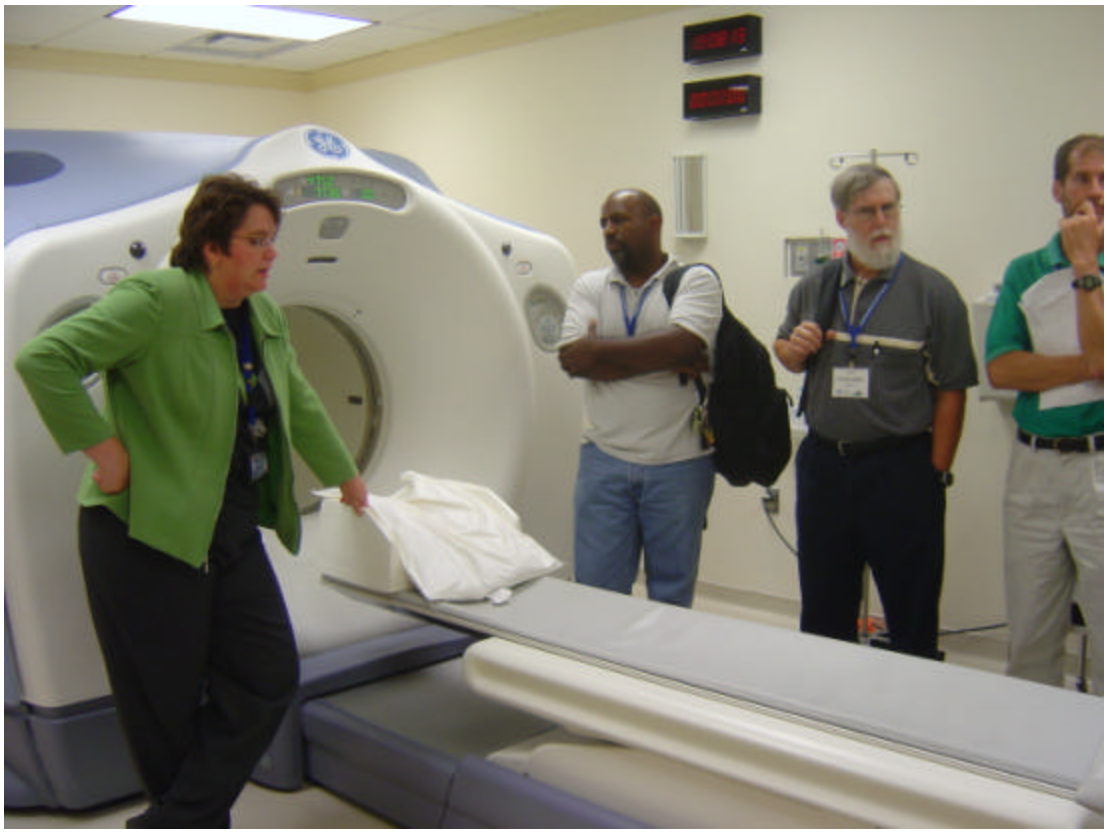
"Demonstration of Gamma Ray counting and spectroscopy with NaI and Ge detectors (Emphasis on source identification)" by Keith Welch

"Use of nuclear science and technology and radiation in the classroom" by Mary Frances Hobbs and Donna Armani.

5.4 Tours

The following tours and visits were organized:

(1) Medical College of Virginia's nuclear medicine facilities – the tour was a great success, mainly due to the enthusiasm and expertise of the various tour guides and escorts from VCU Medical Facility.



Figures 5-6 – Visit of the VCU nuclear medicine facility

(2) Dinner Social at the Science Museum of Virginia.

Figures 7-8 – Dinner & fun at the Science Museum of Virginia

(3) North Anna Power Station, North Anna Nuclear Information Center, See-Through Reactor, and training simulator. The Information Center is accustomed to welcoming tour groups that range in age from grade school on up, so their presentations to our group of teachers were very polished. The visit included a demonstration of a "see-through reactor", where water is heated (electrically) in a glass reactor vessel. All three loops (primary, secondary, and condenser) of a pressurized water reactor are included in the model, as well as a turbine-generator set and a control panel. Our group also visited the control room simulator, where one teacher had a chance to control the water level in a steam generator with a failed level indicator.

Figure 9 – North Anna Nuclear Information Center

Figure 10 – Wilson Madison demonstrating the See-Through Simulator

5.5 Discussions/Guest Speakers

Two out of three dinners had guest speakers: Dr. Andy Cook from AREVA (on Wednesday) and Mr. Brent Dixon from the Idaho National Laboratory (INL) (on Friday). The evening activities were opened to the members of the local sections; the goal was two-fold: first, it allowed the teachers and section members to mingle and get acquainted so that the section members would become a resource for the teachers to call upon if they have questions in the future, and second it gave the section members the opportunity to listen to the guest speakers talk about very interesting topics.

5.6 Post-Workshop Assignment and Examination

Following the workshop, the teachers were emailed an assignment and an online exam

- Provide the answers to their own three questions (provided as a part of the pre-workshop assignment)
- Test online (multiple choice test) (Attachment 3).
- Prepare and submit a lesson plan using the material provided during the workshop

The submission of this assignment was required in order for the teachers to obtain a Certificate of Completion from the local sections and to have the local sections apply for three Continuing Education Units on their behalf with VCU's School of Education.

The workshop, including the lectures, labs and demonstration, tours, discussion periods, pre-workshop assignment, and post-workshop assignment and examination amounted to thirty contact hours with instructors.

A total of 35 certificates of completion and CEU applications were fulfilled. Teachers that failed to submit their post-workshop assignments, including any make-up assignments to cover for missing instruction hours, did not get any credit for the workshop.

6. Lodging and Meals

The teachers and five staff members were provided with single-occupancy accommodations for three nights at the West Grace Street Student Hall. The staff strongly encouraged all the teachers to stay at the dorms, even those that lived in the Richmond area, to build camaraderie and relationships between the teachers and the staff.

All breakfasts (except Saturday) and lunches took place at the Shafer Court Cafeteria. The same VCU identification card that was used for the Student Hall also contained Cafeteria pre-paid passes. Snacks and refreshments were also provided during the various breaks.

All three dinners were catered: two were catered at the School of Engineering by VCU Catering and one was catered at the Science Museum of Virginia by Mosaic. Since the Shafer Court Cafeteria was not open early Saturday, breakfast was provided at the VCU School of Engineering by Panera Bread, who donated bagels, cream cheese, and pastries.

7. Teachers' Evaluations

At the end of the workshop, the teachers completed evaluation forms, and their responses indicated that the workshop was extremely successful. Table 7.1 summarizes the responses. Among the most dramatic responses was the change in the participants' ratings of their knowledge of nuclear energy and radiation basics between the beginning and the end of the workshop. Accommodations and meals were the two areas that received the lowest ratings. Technical aspects of the presentation were highly rated across the board.

These are some selected quotes from the teachers' feedback:

> "Thanks for a great workshop. It was one of the better workshops that I have attended. I liked how the instructors were experts. Very well organized!"
>
> "Exceptional opportunity at terrific price. Exceptionally informed presenters."
>
> "Beyond expectations. Very well done. Very comprehensive."
>
> "This exceeded my expectations. I changed my thinking about nuclear power plants (180° turnaround). I'm now in favor of them. The introduction by Andy Cook was great. He left us wanting to learn more."
>
> "I feel that I can better explain concepts to my students. I also feel more confident in my knowledge. I am glad to have the materials to take back with me for reference."

"I was impressed by the depth of the material presented and pleased that it wasn't simply topics I can teach. It was material that made me more knowledgeable all around."

"Actually it exceeded my expectations. I knew I would learn a lot, but the varied methods of presentations (tours, labs/demonstrations, lectures) cemented the information in my mind. I loved it."

Table 7.1: Summary of teachers' evaluations

How would you rate...	Poor	Fair	Average	Good	Excellent
Your knowledge of nuclear energy & radiation basics before the workshop?	76.9%			23.1%	
Your knowledge of nuclear energy & radiation basics after the workshop?	10.2%			89.8%	
Overall knowledge of speakers?	0%			100%	
Overall quality of speakers?	10.2%			89.8%	
Overall quality of presentations?	12.8%			87.2%	
Overall value of handout materials?	15.8%			84.2%	
Lodging accommodations?	64.9%			35.1%	
Meals?	30.8%			69.2%	
Overall organization of the workshop?	12.8%			87.2%	
Tour of Nuclear Medicine facilities?	7.5%			92.5%	
Tour of North Anna Power Station?	0%			100%	
Pre-Workshop Homework Assignment	34.2%			65.8%	
Overall value of the workshop?	7.7%			92.3%	

8. Post-Workshop Follow-Up

The teachers were provided with a form that offered them the opportunity to request support in preparing for their classroom and laboratory work on nuclear energy, and about one third of them requested such support. One of the instructors has volunteered to coordinate this follow-up support to ensure it gets done at the time specified by the teachers (to match up with their teaching curriculae). The organizers hope that this follow-up support may become significant as an additional means of outreach.

The lesson plans provided by the teachers as part of their post-workshop assignment could be used in the future as ways to present topics related to nuclear energy, and to provide ideas of hands-on activities for other teachers or members of the public. They may prove useful for other public information activities pursued by the sections, such career fair support, Earth Day events, etc.

9. Conclusion

By all accounts, the 2006 Three-Day Science Teacher Workshop was a resounding success. The feedback received from the teachers indicates that the vast majority of them found the workshop extremely useful and helped them gain an improved understanding of all things nuclear. This will in turn result in many classes of better-educated students, who will be better equipped to make sound decisions about energy policy and technology. Also, the rapport created with many of the teachers during the workshop will hopefully provide for future outreach opportunities, and will help establish ANS and ANS members as a reputable source of information for nuclear related topics.

Financially, the workshop was also a success, as the organizers were able to raise enough funds to cover the budgeted costs, and were also able to keep all the expenses well within the budget. This has resulted in a little bit of seed money left over to start the preparations of next year's multi-day science teacher's workshop.

Since this was the first time that the Virginia local sections embarked in such an ambitious project, it took some extra effort to scope many of the pieces involved in the organization of the workshop. However, with this successful first experience we feel that the organization of future workshops will be smoother and more streamlined. Furthermore, all feedback provided from the teachers and all lessons-learned have been carefully compiled and will be used as a key ingredient for the planning of next year's workshop to ensure that the quality of our workshops grows every year and that we are able to meet teachers' needs.

As a side benefit, the successful completion of this challenging project has helped invigorate the Virginia local sections, providing them with an excellent team building experience that also helped recognize the personal talents of each individual volunteer. All volunteers involved in this project were extremely energized at the end of the workshop (although very tired!), and look forward to starting the preparations for next year's workshop.

Attachment 1

Program

(4 pages)

3-DAY SCIENCE TEACHER WORKSHOP
"SCIENCE OF NUCLEAR ENERGY & RADIATION"

Rev. 16 (07/15/2006)

WEDNESDAY, JULY 19, 2006			
4:00 PM	Registration	All	VCU Engineering Atrium
5:00 PM	Dorm check-in and long-term parking	All	West Grace St. Hall West Main St. Parking Deck
6:00 PM	Welcome, course introduction and logistics Discussion of Pre-workshop HW assignment and course expectations	Ms. Sophie Gutner (Dominion)	VCU Engineering Auditorium
7:30 PM	Dinner Keynote Speaker	Dr. Andy Cook (AREVA)	VCU Engineering Atrium

THURSDAY, JULY 20, 2006			
7:00 AM	Breakfast	-	VCU Dinning Hall
8:15 AM	Radiation and nuclear energy basics	Mr. Keith Welch (Jefferson Lab)	VCU Eng. Room #103
9:15 AM	Biological Effects of Radiation	Ms. Beth Hilt (Dominion)	VCU Eng. Room #103
10:15 AM	Break	-	
10:30 AM	Discussion	-	VCU Eng. Room #103
10:45 AM	Beneficial uses of Nuclear Science and Technology	Dr. Sama Bilbao y León (Dominion)	VCU Eng. Room #103
11:45 AM	Lunch	-	VCU Dinning Hall
12:45 PM	LAB 1: Geiger meter survey, its care and use in the classroom [1/2 class]	Dr. Reed Johnson	VCU Eng. Room #237
	LAB 2: Demonstration of Gamma Ray counting and spectroscopy with NaI and Ge detectors (Emphasis on source identification) [1/2 class]	Mr. Keith Welch (Jefferson Lab)	VCU Eng. Room #103
2:15 PM	Break	-	
2:30 PM	LAB 1	Dr. Reed Johnson	VCU Eng. Room #237
	LAB 2	Mr. Keith Welch (Jefferson Lab)	VCU Eng. Room #103
4:00 PM	Trip to MCV Medical facility		
4:30 PM	Nuclear Medicine (Lecture and tour of the MCV facilities: Cyclotron, PET Scanner and Radiochemistry Lab)	Dr. Crosthwaite (VCU Nuclear Medicine Technology) Mr. Paul Riley (VCU School of Radiation Sciences) Ms. Sharon Gibbs (VCU Nuclear Medicine and Molecular Imaging Center)	MCV Hospital
6:30 PM	Trip to Science Museum of Virginia (SMV)		
7:00 PM	Dinner @ Science Museum of Virginia	-	SMV
8:00 PM	Discussion of Radiation related issues: Biological Effects, Hormesis, Chernobyl Effects, etc	Moderator: Dr. Sama Bilbao y León (Dominion)	SMV

FRIDAY, JULY 21, 2006			
7:00 AM	Breakfast		VCU Dinning Hall
8:15 AM	Nuclear Power Fundamentals	Mr. Todd Flowers (Dominion)	VCU Eng. Room #103
9:15 AM	Reactor Safety	Dr. Ross Anderson (Dominion)	VCU Eng. Room #103
10:15 AM	Break	-	
10:30 AM	Discussion	-	VCU Eng. Room #103
10:45 AM	The nuclear fuel cycle (Part 1): Mining, enrichment and fuel fabrication	Mr. Joe Montague (Dominion)	VCU Eng. Room #103
11:30 AM	Lunch	-	VCU Dinning Hall
12:30 PM	The nuclear fuel cycle (Part 2): Used nuclear fuel management (Yucca Mountain, Utah, reprocessing, etc)	Dr. Kevin McCoy (AREVA)	VCU Eng. Room #103
1:30 PM	The Future of Nuclear: New nuclear plant construction, Nuclear Economics and the Hydrogen economy	Mr. Marvin Smith (Dominion)	VCU Eng. Room #103
2:30 PM	Discussion	-	VCU Eng. Room #103
2:45 PM	Break	-	
3:00 PM	Use of nuclear science and technology and radiation in the classroom	Mrs. Donna Armani (Chemistry Teacher, Briar Woods High School, Loudoun County) Mrs. Mary Frances Hobbs (Chemistry Teacher, Huguenot High School, City of Richmond)	VCU Eng. Room #103
5:00 PM	Break	-	
6:30 PM	Dinner Keynote Speaker	Dr. Kathryn McCarthy (INL)	VCU Engineering Atrium
7:30 PM	Nuclear power issues: Proliferation, energy resources, sustainability, economics, etc	Moderator: Dr. Reed Johnson	VCU Engineering Atrium

SATURDAY, JULY 22, 2006			
7:30 AM	Breakfast		VCU Engineering Atrium
8:00 AM	Check out		VCU Engineering Atrium
8:45 AM	Leave for North Anna Power Station		
10:00 AM	Arrive at North Anna Nuclear Information Center (NANIC)		
10:30 AM	Introduction to North Anna	Mr. Bruce Evans (Dominion) Mr. Mike Duffey (Dominion)	NANIC
11:00 AM	GROUP 1: See-Thru Reactor and NANIC Tour [1/2 Class]	Mr. Mike Duffey (Dominion) Mr. Wilson Madison (Dominion)	NANIC
	GROUP 2: Visit to the NAPS Simulator [1/2 Class]	Mr. Richard Stevens (Dominion)	Training Building
12:30 PM	Lunch		NANIC
1:30 PM	GROUP 1	Mr. Mike Duffey (Dominion) Mr. Wilson Madison (Dominion)	NANIC
	GROUP 2	Mr. Richard Stevens (Dominion)	Training Building
3:00 PM	Course closure, evaluations	All	NANIC
4:00 PM	End of course		

Attachment 2

Pre-Workshop Homework Assignment

Questions

GENERAL - MISCELLANEOUS

(1) How does the ANS plan to educate communities about the benefits and risks involved in building or adding to nuclear power plants?

(2) What are some of the more important issues about nuclear energy I should discuss with my students? How can I bring nuclear energy down to a level that 8th graders will understand?

(3) How to better educate the public to the actual risks associated with radiation and radiation exposure?

(4) What are the cultural issues that have lead some countries to fully accept nuclear power? I believe that France and Japan are major users or nuclear power. How do their citizens feel about it?

(5) What happens to a nuclear reactor after it reaches the end of its service life?

(6) What other methods of radiometric dating are in use besides Carbon-14?

(7) What is being done to change the public's negative connotations regarding nuclear power?

(8) Is Dominion Power involved in the presentation of this workshop?

(9) What type of advertising or public awareness is being done to promote nuclear power in Virginia, if any?

(10) How can I impress upon the students the importance of knowing the facts to make informed decisions about nuclear power?

(11) It seems the polls are showing that more than 50% of all people are interested in developing new nuclear energy facilities. In spite of the fact that money is a big problem what can we do to encourage growth and development in the area of nuclear energy?

(12) Do the energy companies like Dominion Power and others have campaign representatives to educate the public and the students in our Virginia Schools?

(13) How can citizens encourage our government to support nuclear power?

(14) How can the average person make a quality decision concerning nuclear reactors if they think the information about them is too complex? In other

words how can the public be educated or reeducated about nuclear power in layman's terms?

(15) How can we best educate the public to calm their fears of nuclear power?

(16) What steps are being taken to "educate" the public about nuclear power as an alternative to coal and oil, to reduce green house gasses, and its safety and reliability?

(17) I would like to learn more about career opportunities that students may have in the nuclear power and nuclear medicine industries – as well as novel ways of presenting these in a physics classroom.

(18) How to we bring nuclear energy concepts down to middle school children's level?

USED NUCLEAR FUEL MANAGEMENT

(1) Will the Yucca Mountain facility ever open?

(2) What type of research is being done to handle nuclear waste?

(3) How does the North Anna Power Station/State of Virginia handle spent fuel now and if they should build another plant how will they handle it, since the Yucca Mountain, Nevada repository is not ready yet?

(4) What do we do if the 10,000 year limit on waste is not lifted?

(5) What are industry's plans (if any) to further minimize risk of terrorist attacks on cross-country shipments of spent fuel?

(6) What is the current status of Yucca Mountain and is it true that new research suggests that it is not as moisture resistant as once thought, and thus the watershed is not as safe as promised?

(7) Is it environmentally foolish to begin more nuclear facilities when there is no solution to the long-term storage facilities issue? When does temporary storage become economically unfeasible, who would become caretakers of these facilities if the power company went out of business?

(8) How much spent fuel or ready to use reactor fuel would subversive groups need to take in order to make a nuclear device capable of killing millions? How hard is it to create a dirty bomb? What safeguards are in place to insure this cannot happen? Saying our reactors are hardened enough to withstand a direct hit by a jet plane is not enough.

(9) How safe or risky is the transportation of the radioactive wastes to the Yucca mountain nuclear waste repository from various parts of the country? If the train derails or in case there is an accident would there be a radioactive spill? How would the other countries dispose off their nuclear wastes?

(10) How is spent nuclear fuel safely transported on our national highway system?

(11) Where do we stand currently on safeguarding all the radioactive by products of nuclear reactors and old Soviet Union war heads?

(12) Breeder reactors: Why haven't they been more successful in France? Apart from the highly radioactive fuel they produce, what are the benefits and drawbacks?

(13) The management and disposal of nuclear waste is a huge problem in the nuclear power plant industry. What is being done by the industry and the government to solve this problem while waiting for the availability of the Yucca mountain waste repository?

(14) Where does the possible selection of Yucca Mountain as a long-term geologic repository stand in terms of congressional funding/determination?

(15) How fast and in what quantity does nuclear waste accumulate over time, how is it now disposed of and stored in Virginia and how much longer can the status quo be maintained?

(16) How much radioactive waste does a typical nuclear power plant generate in a year's time? Over its operating lifetime?

(17) What is going on with the Yucca Mountain Waste Repository project? How much longer can Virginia power plants store spent fuel if this project is scrapped?

(18) Is there any research being done that could use nuclear energy but not have the spent fuel? Is putting it in casks really the best way of disposing of it?

(19) How will the nuclear waste be transported to Yucca Mountain after the site is ready?

(20) What is the progress toward the creation of the Yucca Mountain site for waste disposal?

(21) How does storage in water tanks make the spent fuel less dangerous (radioactive)?

(22) Why are there different government standards for nuclear use and waste for the military and commercial arenas? (Pg. 29-30 of Roberds article, Managing Spent Fuel)

(23) How does Dominion plan on dealing with the long-term storage of nuclear material especially as their storage sites begin to fill?

(24) How should the international community address increased stockpiles of nuclear material especially within unstable segments of the world?

(25) Will the Yucca Mountain facility ever be completed? If not, then what is the alternative for disposing of the spent fuel?

(26) Is there research going on to find ways to safely recycle the nuclear waste?

(27) Is the Yucca Mountain project still slated to be completed by 2010? What security measures will be in place to protect the facility and the transportation of waste across the U.S.? How is the transportation going to take place (train, plane, truck, etc)?

(28) Disposal of nuclear waste and the effect on the environment.

(29) How can nuclear waste be transported/stored/disposed safely and securely?

(30) How soon does Yucca Mountain have to be on line before serious storage problems (i.e., reactor shut down) come about?

(31) What are the plans for long term radioactive storage facilities such as Yucca Mountain?

NEW NUCLEAR – NUCLEAR IN VIRGINIA

(1) I know that President Bush favors the renewed construction of nuclear plants as part of his energy policy. What happens if plans are underway to build a new plant and the next President elected has a different view? How much of this is dictated by the government?

(2) What about the new "Generation IV" reactors?

(3) Problems facing us with the current power grid.

(4) When can we expect to be finished with fossil fuels?

(5) Is it conceivable that nuclear energy could solely take over the power market, thus reducing polluting emissions and America's dependence on foreign oil, which are concerns with current energy sources? If so, how soon could this power shift be expected?

(6) There have been such great investments in the areas of wind and solar power, yet they continue to be written off as being ineffective for large-scale power production; is there any hope for these renewable resources to ever see national success, or have these efforts been futile?

(7) What does the statement below mean? "Dominion, said at an energy conference in May 2004 that to build a new nuclear plant today would take at least six-and-one-half years and more than $2.5 billion, financed on a 50/50 equity basis. If you announced you were going to build a new nuclear plant, Moody's and Standard & Poor's would assuredly drop your bonds to a junk status."

(8) How is the nuclear industry going to avoid protester legal stonewalling like we saw in Seabroke, NH? (This delays construction and increases total cost that rival fossel fuels.)

(9) Can weapons grade material be recycled to be used in nuclear reactors?

(10) What types of testing has been done on the new nuclear power plant designs to prove they are safe? I am curious to hear about safety from "nuclear melt downs" and long-term environmental safety of the area surrounding the nuclear power plant.

(11) What is the total cost per kWh (over 15 years) of nuclear, coal, oil and natural gas power plants if the cost of building and inspecting the plants is factored into the equation?

(12) Are our existing plants reaching life limits?

(13) Are our designs for future plants "state of the art?"

(14) Can the U.S. lead the world in safe use of Nuclear Power?

(15) Keeping up with the demand for electricity despite the cost and time of building nuclear power reactors.

(16) Updated information on nuclear fusion and its role as an energy source.

(17) Dealing with the high cost to construct new nuclear power plants.

(18) If nuclear power is so cost competitive, why is a Nuclear Power plant not able to recapture the cost of it's initial construction through it's long term operation?

(19) In general what is the cost effectiveness of building a new nuclear power plant versus reopening one that has closed? I bring this up since the Trojan Nuclear Power Plant in Oregon was imploded this past May. What would the cost of demolition be versus the cost of modifying the plant? I'm sure this plant had many issues against it, but for the average person seeing this in the news would say, "What a waste of time and money when they are trying to build new plants."

(20) Is it possible that the government would finance a venture to become the world's provider of electrical power?

(21) Are there approved plans for new power plants?

(22) How has "energy capacity" increased to 91%, since the plants were built in the 70s? How is the plant more efficient?

(23) How is the "passive safe" design an improvement over earlier reactors?

(24) Is it appropriate for the US to continue its use of nuclear power and nuclear armament when we are asking other countries to disarm and use different energy resources?

(25) How far behind are we in the usage of nuclear fusion for the production of Electricity?

(26) What is the life expectancy of a nuclear power plant in the U.S.?

(27) How was the decision made that the materials of Nuclear plants originally projected to survive 20 years have now been deemed viable for another 20 years?

(28) Why is nuclear plant construction considered so financially risky by Moody's and Standard and Poor's given the many advantages that nuclear power offers?

(29) What are the new designs for nuclear power plants? I heard about the "passively safe" design and saw an article some years back in Popular Science about a nuclear reactor that had the fuel encased in graphite (?) spheres.

(30) How can the cost factor of nuclear power compare to current power facilities (in the short and long term)?

(31) Given the fact that fossil fuels pollute the atmosphere and lead to global warming, how much of the environment is affected by radiation poisoning and must be sealed from living organisms. This would include both the recovery and processing side of the fuel cycle and the spent fuel storage side of the cycle. A lot is said about the safety of the power plant and its lack of radioactive emissions during fuel use. What is the safety record for miners, people working in processing facilities, etc?

(32) The increased attention to "clean coal" technology by the current (federal) administration – how might this affect Dominion's plans to invest in additional nuclear plants?

(33) Besides the cost and the time to built it what others factors if any exists has caused the construction of nuclear power plants to diminish since 1973?

(34) Where do we currently stand in the country on research of fission reactors?

(35) Where are we currently standing in the process of possibly building new reactors?

(36) Have the residents around facility Lake Anna voiced any opposition to Dominion Power's application for a permit to site a new unit at that facility?

(37) How is thermal pollution being minimized?

(38) Where does Dominion's application for a site permit to possibly construct a new nuclear power unit at Virginia's Lake Anna nuclear power plant stand?

(39) Currently, nuclear power produces about 35% of the electric in VA. Ideally, what percent of Virginia electric power needs do nuclear power advocates propose will produce in the future and when might this be in place?

(40) Public opinion seems to be in favor of building more nuclear power plants but how many of them would want to begin paying now for something that they might benefit from for 10 years in the future?

(41) Besides nuclear power, which obviously brings health risks, what other promising sources of energy are currently being researched? (Hydrogen power, photovoltaic cells, biofuels, etc.)

(42) Discuss power plant energy equivalency = how many nuke power plants would equal one fossil fuel plant or vice versa?

(43) If all 103 were taken off line, how many more power plants would have to be built?

(44) How many power plants have been built around the world since 1973?

(45) How long does it take to construct nuclear power facilities? How much maintenance is required?

(46) What other countries are leaders in nuclear energy production?

(47) What is the current status of research into fusion reactors and how might they compare to what we have now?

(48) Should more nuclear power plants be built before it is decided what to do with the waste?

(49) Is it possible to manage fusion reactions in order to have a better energy source for the future? Is there a possibility for fusion reactors to decrease in cost over the next several years?

RADIATION AND HEALTH EFFECTS

(1) Have there been any scientific links made between nuclear radiation exposure and mental retardation and/or any other mental/physical disabilities? If yes, are there any residual effects passed on to future offspring?

(2) I would like to know more about the affects of radiation on the human body as this is a question often asked by students.

(3) Is there any correlation between nuclear power plants and the number of children affected with ADD/ADHD? (Saw this presented at the ASSS Conference two years ago.)

(4) What are the advantages of becoming an agreement State?

(5) How far along in the process is Virginia in becoming an agreement State?

(6) I would like an easy way to understand conversion of units of radiation.

(7) I have several unidentified radioactive samples, is there a way to identify them?

(8) What are the dangers and precautions of living near a nuclear power facility?

(9) What is the relationship between the units used to measure radiation, such as rems, rads, grays, roentgens, etc.?

(10) What is the meaning and application of dose equivalent and effective dose and how are they related?

(11) What is the difference between direct and indirect ionizing radiation and their effects?

NUCLEAR POWER OPERATIONS (SAFETY & SECURITY)

(1) Would the Containment Building withstand a direct hit from a large aircraft? The federal government has determined that a nuclear power plant could withstand a direct hit from a large aircraft without it penetrating the reactor vessel and causing a major accident.

(2) Safety concerns regarding the issue of terrorism.

(3) What are we doing to insure the well being of the people when it comes to safety issues such as terrorist attacks and radiation leaks?

(4) How does a nuclear reactor work?

(5) How protected are reactors from catastrophes such as terrorist attacks and Chernobyl-like explosions?

(6) How much of Hampton Roads would have to evacuate if there were a serious problem at Surry?

(7) How much and what type of annual training or professional development does a nuclear power plant control room operator receive?

(8) The Homeland security issues that have arisen since 9/11. How has security been upgraded since?

(9) How prevalent is the problem of ground water contamination around nuclear power plants? How “bad” of a problem is it?

(10) The Chernobyl and Three Mile Island disasters are still in the memory of most people. What must be done in order to eliminate the negative effects of nuclear power?

(11) What specific security measures have been undertaken at the North Anna and Surry plant sites?

(12) How many nuclear "events" have occurred in the US military (NAVY) and why has this fact not helped the image of the US nuclear industry?

(13) What kind of research continues today in the are of nuclear to improve the overall scheme of getting the actual thermal energy out of the reactor core?

(14) What can be done to insure the safety of nuclear power both in terms of accidents and terrorist threats in countries outside the US?

(15) What can be done to alleviate the public's fear of a nuclear accident and what safety feature do power plants have in place in case of an accident?

(16) Even if the risk is small of having a nuclear disaster, can you put a dollar figure on the lost of lives/damage to lives if it does occur?

NUCLEAR POWER BASICS

(1) I have been given to understand that a neutron must be slowed (to thermal speeds?) for it to successfully combine with a U-235 nucleus and yet I'm not aware of the presence of moderators in atomic bombs or the uranium deposits of Gabon which spontaneously fissioned.

(2) I would like to be able to explain to my students how a nuclear reactor works, and what exacting becomes radioactive during the process, along with the ½ life of some of the fuels used in reactors.

FUEL CYCLE

(1) What is the amount of nuclear fuel available to the United States?

(2) How much uranium is available for nuclear power?

(3) Where is this uranium located? Is it concentrated in certain regions?

(4) How is "enriched" uranium created? How duration of time is a bundle of "enriched" uranium pellets used?

(5) How is uranium "enriched"?

(6) How much natural uranium is available and how many years of energy do we anticipate it could provide?

(7) What is the availability of the fuel for nuclear reactors? How is it isolated?

(8) How and where do we mine uranium and how do we discard it safely?

(9) How quickly does uranium need to be replaced in the power plants and how is this determined?

(10) If every country around the world begins to use nuclear reactors for their future energy needs how long would the Uranium deposits last? Would it be like the current fossil fuel supply? Would the technology of safe usage of nuclear reactors be available to other countries?

Workshop Expectations

At the beginning of the workshop, the teachers were asked to provide their expectations:

* New information post-TMI
* Scout's merit badge on atomic energy
* Non-bomb information
* Latest news on Yucca Mountain
* Uranium procurement and reprocessing
* Nuclear in unstable countries
* Getting information to make informed decisions as voters

Attachment 3

Post-Workshop Online Exam

This Exam is due on August 5th, 2006.

Your Name: _____

1. A radioactive nucleus emits an alpha particle. The atomic number of the new nucleus compared to the original nucleus is _____.

   - ☐ Greater by 4
   - ☐ Smaller by 2
   - ☐ Greater by 2
   - ☐ Smaller by 4

2. What fuel source did most of the power plants built in the United States in the last five years use?

   - ☐ Hydro (water)
   - ☐ Natural gas
   - ☐ Nuclear
   - ☐ Coal

3. Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold are _____ effects.

   - ☐ Stochastic
   - ☐ Somatic
   - ☐ Chronic
   - ☐ Deterministic

4. In order to stop an alpha particle we only need:

   - ☐ A sheet of paper
   - ☐ A sheet of plastic
   - ☐ Two inches-thick lead
   - ☐ Two inches-thick concrete

5. Which of the following foods have been approved for irradiation in the United States?
   - ☐ Eggs
   - ☐ Chicken
   - ☐ Strawberries
   - ☐ All the above
6. One Uranium fuel pellet provides the same energy as:
   - ☐ 1,780 pounds of coal
   - ☐ 149 gallons of oil
   - ☐ 17,000 cubic feet of natural gas
   - ☐ All the above
7. What are the barriers to offsite radionuclide release from a Western nuclear power plant?
   - ☐ Fuel matrix, fuel cladding, reactor vessel, containment personnel hatch
   - ☐ Fuel matrix, fuel cladding, reactor vessel, containment
   - ☐ Fuel pellets, fuel cladding, reactor head vents, containment
   - ☐ Fuel cladding, reactor vessel head vents, containment
8. Choose the particle having a relative mass of 1 amu and no charge:
   - ☐ Alpha particle
   - ☐ Proton
   - ☐ Beta particle
   - ☐ Neutron
9. The advanced nuclear power plants use passive safety systems that rely on:
   - ☐ Several pumps and motors
   - ☐ The natural force of gravity
   - ☐ Human operators
   - ☐ Plant computers
10. A sample of a radioactive element decays to 25% of its original number of radioactive nuclides in 12 years. What is the half-life of this radioactive element?
    - ☐ 4 years
    - ☐ 6 years
    - ☐ 2 years
    - ☐ 3 years

11. What does a negative fuel temperature coefficient mean?

- ☐ Power is reduced as the fuel temperature increases
- ☐ Power is increased as the fuel temperature increases
- ☐ The coolant coefficient increases as the fuel temperature increases
- ☐ The coolant coefficient decreases as the fuel temperature increases

12. Nuclear technologies are used in the manufacturing of cosmetics ...

- ☐ to ensure women glow
- ☐ to obtain more intense shades of blue eye shadow
- ☐ to remove harmful impurities and germs
- ☐ all the above

13. The term that quantifies the difference in the biological effect from different types of radiation is the:

- ☐ rad
- ☐ rem
- ☐ roentgen
- ☐ quality factor

14. The water that cools the reactor is the same water that serves as the ultimate heat sink (lake, river, cooling tower).

- ☐ True
- ☐ False

15. In a chain reaction, where K=1:

- ☐ The reactor is supercritical, and the neutron population is continuously increasing.
- ☐ The reactor is critical, and the neutron population is constant.
- ☐ The reactor is subcritical, and the neutron population is decreasing.
- ☐ The reaction is not controlled, and it is impossible to know whether the neutron population is increasing or decreasing.

16. Which of the following is NOT a type of ionizing radiation?

- ☐ Alpha particles
- ☐ X-Rays
- ☐ Beta particles
- ☐ Microwaves

17. The presence of a nuclide that decays by positron emission can be verified by:

- ☐ The build-up of helium gas near the sample
- ☐ A mysterious blue glow
- ☐ Mass spectroscopy
- ☐ Detection of 511 keV "anhililation" photons.

18. A renewable energy source is one that does not emit greenhouse gases

- ☐ True
- ☐ False

19. What is true about a Positron Emission Tomography (PET) scan

- ☐ There is radiation that passes through the patient and allows the doctor to see inside the patient's body
- ☐ The radiation is emitted by the patient's body due to a radiopharmaceutical
- ☐ It is routinely used nowadays for diagnosis of most diseases
- ☐ All the above

20. Uranium used as nuclear fuel is enriched to about _____ , whereas the material used to make nuclear weapons is enriched to about _____.

- ☐ 4%, 90%
- ☐ 50 %, 50%
- ☐ 60%, 40%
- ☐ 90%, 4%

21. The daughter product left after beta decay has:

- ☐ the same number of protons as the original nucleus
- ☐ one more proton than the original nucleus
- ☐ one less proton than the original nucleus
- ☐ an unpredictable number of protons

22. What fuel source has contributed most to reducing greenhouse gas emissions in the United States?

- ☐ Hydro [water]
- ☐ Natural gas
- ☐ Nuclear
- ☐ Coal

23. The host rock for the repository at Yucca Mountain is

- ☐ domed salt
- ☐ bedded salt
- ☐ tuff
- ☐ basalt

24. According to the _____ dose-response theory, exposure to low doses of radiation may result in a positive effect, including increased life span and reduction in cancer incidence.

- ☐ linear (non-threshold)
- ☐ linear-quadratic
- ☐ threshold
- ☐ hormesis

25. What can you, as educators, do to ensure the future supply of clean, reliable and economical energy?

- ☐ Train new scientists, engineers and skilled labor
- ☐ Interest students in building and constructing new things
- ☐ Explain how technology can help promote sustainable development and support environmental protection
- ☐ All the above

Submit Exam Reset