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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

SUBCOMMITTEE ON ADVANCED REACTORS

Monday,

June 4, 20001

Rockville, Maryland

The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Auditorium, 11545 Rockville Pile, at 9:00 a.m., Thomas S. Kress, Chairman, presiding.

COMMITTEE MEMBERS:

THOMAS S. KRESS

GEORGE APOSTOLAKIS

MARIO V. BONACA

F. PETER FORD

GRAHAM M. LEITCH

DANA A. POWERS

WILLIAM J. SHACK

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9:02 a.m.

DR. KRESS: I don't have a gavel to convene this meeting, but I'll pretend I have, so the meeting will now please come to order.

This is the first day of the meeting of the ACRS Subcommittee on Advance Reactors.

I'm Thomas Kress, the Chairman of this Subcommittee.

Subcommittee members in attendance are ACRS Chairman George Apostolakis, Mario V. Bonaca, Graham Leitch, Dana Powers, William Shack, Jack Sieber, Robert Uhrig and Graham Wallis.

Also attending is ACNW Chairman John Garrick.

The purpose of this meeting is to discuss matters related to regulatory challenges for future nuclear power plants. The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions, as appropriate, for deliberation by the full committee.

Michael T. Markley is the cognizant ACRS staff engineer for this meeting.

The rules for participating in today's meeting have been announced as part of the notice to this meeting, previously published in the Federal Register on May 10, 2001.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

So that we can effectively manage the time and allow for a maximum member, presenter and public participation in sharing, the Subcommittee has set down some rules of engagement, I guess we can call it, or the following protocols. Please pay attention to these.

Number one, the presenters should be allowed to make their presentations without substantial interruptions. Questions from the audience and stakeholders will be entertained at the end of presentation sessions, not the individual presentation. So keep your questions in mind, you may even want to write them down.

Members of the public and audience should use question cards that we have supposedly provided to you. The ACRS staff facilitator Mike Markley will collect these and group them as practical and read them into the record, and refer questions and comment to questions to presenters and/or panel participants as appropriate.

It may not be possible to respond to all questions and comments, however all questions and comments will be listed in the meeting proceedings following the workshop.

Opportunities for direct audience participation will be provided during panel discussion sessions each day. Microphones have been arranged for convenience of the audience during this meeting. So it is requested that speakers identify themselves and speak up with sufficient clarity and volume so they can be readily heard.

I would like to remind speakers and the audience that we set down some things that we want the audience and the speakers and the presenters to address. And I'd like to repeat what these are so that we can focus correctly in this meeting.

One, we want to describe the design and key safety features and status of the development of the design for the various concepts.

We want to provide the planned license application and deployment schedules, if available.

We want to identify licensing challenges and opportunities as compared to Gen II reactors. I think that's the major thing we want to get out of this meeting, is to identify the licensing challenges.

We want to discuss planned approach to licensing, construction and operation as compared to that currently used for Gen II reactors.

And this is another important element, what changes are needed in the current NRC and industry licensing infrastructure? Do the schedules adequately support the planned Gen IV license applications and employments. That's the licensing schedule.

And a general comment, what if any additional initiatives are needed.

So, with that as a statement of what we're after here, I'll turn to the microphone over to our Chairman Dr. Apostolakis.

DR. APOSTOLAKIS: I'm very pleased to introduce our keynote speaker for this workshop, Commission Nils Diaz. Dr. Diaz was serving as a Commissioner of the U.S. Nuclear Regulatory Commission in August 1996. Prior to that time Dr. Diaz had a distinguished career in nuclear and radiological engineering as a scientist, engineer, researcher, consultant and entrepreneur.

In the research and development arena, Commissioner Diaz worked for mundane light water reactor safety and advanced designs to more complex space power and propulsion systems and on the conceptual design and testing of futurist reactors like the UF-6, UF-4 and uranium metal fueled reactors for the Strategic Defense Initiative.

Commissioner Diaz?

COMMISSIONER DIAZ: Thank you. I think I'm going to stand.

Well, good morning. That last part of the introduction was just to kind of let you know that, you know, although some of these new reactors might sound advanced, there were other monsters around that were a little more difficult to work with.

I am reminded of the time that we actually work with a reactor in which we only had to have it working for minutes. How is that we only had to have that reactor on and for three minutes? So somebody finally said let's make things simple. Let's make things very simple. Let's do away with everything else. We just take uranium metal and start inject into this reactor, it will be vaporized and we'll have a uranium vapor reactor which will run and the core was perfectly fine. It would run, very well for three or four minutes. There was no problem. Looked over all the core calculations, and looked at everything else and everything was fine. It will actually probably run.

There was minor detail, one of these practical little details. It was the nozzle to inject the reactor fuel, which of course the reactor was liquid at the time. And no matter where we put it, it will have a density of about, oh say, neutral blocks of 10 to the 18 neutrals per square centimeters per second, which power density will vilify the nozzle, the fuel before it gets to the reactor.

So, those were the problems, and those real problems.

I'm very really very, very pleased to be talking with you today. This is an issue that, of course, is very important to the country and it is particularly appropriate that the Advisory Committee on Reactor Safeguards is hosting this meeting at this time.

The discussion on nuclear power has now fully entered the national debate on the future of America's energy supply and nuclear safety is going to be a priority on everybody's agenda. The Commission relies on ACRS for expert advice, safety of reactors existing or submitted for licensing. The recommendations of the Committee will be of particular value to the Commission as we deliberate the licensing.

I will be presenting my individual views today. They do not necessarily represent the views of my fellow Commissioners or the Agency.

I want to premise my remarks from a few selected quotes from a "couple" of speeches during my tenure as a Commissioner, just to set the tone from where I'm really going to.

So let me start with a quote that I believe is of extreme value.

- "There is no credible regulator without a credible industry. And there is no credible industry without a credible regulator."
- "It is essential for the regulator to be cognizant of the technology. It is essential for the industry and technologists to be cognizant of the regulations."
- "Regulations need to result in a benefit or they will result in a loss." There is no reason to be any regulations unless

they will benefit society.

- "My goal is to ensure the paths are clearly marked." That has been really kind of what I've tried to do during my years. "A path that is clear of obstacles and unnecessary impediments, with well defined processes, will provide regulatory predictability, equity and fairness."
- Again, another one: "We are learning how to define adequate protection in more precise terms, and to define it in terms that make sense to the American people."
- And finally, "We have learned from our mistakes and we are bound not to repeat them." This last point, I hope that you prove me right.

At the 2001 United States NRC Regulatory Information Conference, I said "We might be asked, as would other government agencies and the private sector, to sharpen our skills, and improve our efficiency to meet the needs of the country." We have been asked. It is worthwhile to try to understand why the President and the Vice President of the United States have brought nuclear power generation centerstage in the debate of the energy policy of our country.

Shown in the next figure it's a compilation of important aspects of the debate, summarizing what has changed in 20 years. All of these issues are known to you, both economically from the regulatory side. Everything that had to do with productivity, all of those things have actually changed. A few things have remained the same. For example, it is important to national security that we have a stable generating base that will anchor the electrical generation in this country. But many of the other things have changed as the bottom line changed from low predictability to good predictability. It is our job to change it from good to high.

The NRC has been changing to meet the challenge of what must be changed and to strengthen what must be conserved. I submit to you that we have changed for the better, especially the last three years, and that improvements in regulatory effectiveness and efficiency are changing from goals into reality. But it has not been easy, as many of you know, and there are still lessons to be learned.

I must say, though, that there is one

change that I believe speaks louder than words for the NRC staff and the agency as a whole: Priority is now placed on what should be done better rather than on what was done wrong. And this is a major cultural change.

This cultural change is needed to enable the consideration of newer, better and enduring ways to exercise the mandate entrusted to the NRC by the people of this country: To license and regulate the peaceful uses of nuclear energy, with adequate assurance of public health and safety.

I believe that we are now capable of meeting the regulatory challenges that we face today regarding advanced nuclear plants. The improve industry performance over the past decade has enabled the NRC to initiate and implement reforms that are progressively more safety-focused. Furthermore, it allowed the industry to concentrate resources on the issues important to safety which provided a sharper focus to regulatory improvements. Safety and overall performance, including productivity, became supporters of each other, with the clear and unmistakable proviso that safety is first.

For existing nuclear power plants, the list of profound regulatory changes and accomplishments, many done under the mantle of the so-called risk-informed regulation, would occupy the rest of this meeting. Skip them. But five of them stand out: The revised rules on changes, tests, and experiments, the § 50.59, the new risk-informed maintenance rule; the revised reactor oversight process; new guidance on the use of PRA in risk-informed decision-making (Regulatory Guide 1.174); and the revised license renewal process.

The list is growing. About two weeks ago, the Commission approved COMNJD-01-0001 instructing the staff to give priority to power uprates, bring it up the priority list, make it a real purpose of the Agency and allocate appropriate resources, streamline the NRC power uprate review process to ensure that it is conducted in the most effective and efficient manner. All of these and most of the other regulatory improvements conform to the Commission's decision to focus attention on real safety. The resulting improvements in rules, regulations and processes, including changes to the hearing process and enhanced stakeholders participation, are assuring the nation that a fair, equitable and safety-driven process is being used.

I mentioned risk-informed regulation, and

I can see Chairman Apostolakis a little more lively in here, as an important component of the changes NRC regulatory structure. And I firmly believe it is an important point. I want to be sure you know what I mean, what I personally mean when I use the term risk-informed regulation, so I'm going to present you with my own personal definition of it:

> Risk-informed regulation is an integral, increasingly quantitative approach to regulatory decision-making that incorporates deterministic, experiential and probablistic components to focus on issues important to safety, which avoids unnecessary burden to society.

And I think you know most of these things. I really want to focus on why I am extremely attracted to risk-informed regulation, and it's the last sentence, which avoids unnecessary burden to society. And I firmly believe that that is the test.

The definition can also be used for risk-informed operations, risk-informed maintenance, risk-informed engineering, risk-informed design, whatever you want to.

For new license applications, much groundwork has been done, and a lot of it is useful to address today's issues. Going back in history in the statement of considerations for 10 CFR Part 52, the Commission stated that the intent of the regulation was to achieve the early resolution of licensing issues and enhance the safety and reliability of nuclear power plants. Nothing wrong with that.

The Commission then sought nuclear power plant standardization and the enhanced safety and licensing reform which a standardization could make possible. In addition, 10 CFR Part 52 process provides for the early resolution of safety and environmental issues in licensing proceedings.

The statement of considerations for 10 CFR Part 52 goes on to say, and it's a very interesting statement "The Commission is not out to secure, single-handedly, the viability of the [nuclear] industry or to shut the general public out." In essence, it's continuing to quote "The future of nuclear power depends not only on the licensing process but also on economic trends and events, the safety and reliability of the plants, political fortunes, and much else. The Commission's intent with this rulemaking is to have a sensible and a stable procedural framework in place for the consideration of future designs, and to make it possible to resolve safety and environmental issues before plants are built, rather than after."

In February of this year, the Commission directed the staff in COMJSM-00-0003 to assess its technical, licensing, and inspection capabilities and identify enhancements, if any, that would be necessary to ensure that the agency can effectively carry out its responsibilities associated with an early site permit application, a license application and the construction of a new power plant.

In addition, the Commission directed the staff to critically assess the regulatory infrastructure supporting both 10 CFR Parts 50 and 52 with particular emphasis on early identification of regulatory issues and potential process improvements. The focus of these efforts is to ensure that the NRC is ready for potential applications for early site permits and new nuclear power plants.

I repeat, the purpose of these efforts is to ensure that the NRC is ready for potential applications for early site permits to certify designs or designs to be certified, and that the NRC does not become an impediment should society decide that additional nuclear plants are needed to meet the energy demands of the country.

In this case, let me assure you that the Commission I'm sure will be interested on necessary safety-focused regulations, definitely yes. Unnecessary, not safety-focused regulations, no. The staff is working hard to carry out this direction and I am sure you will hear about some of our efforts over the next two days.

Risking being repetitive, I'm going to re-start at the beginning, and I know that I sound strange, but it's really at the very beginning.

The U.S. Nuclear Regulatory Commission has a three-pronged mandate:

- Protect the common defense and security.
- To protect public health and safety, and
- To protect the environment.

by the licensing and regulation of peaceful uses of atomic energy. I have long advocated that an adequate and reliable energy supply is an important component of our national security. An important component of our national security. And I firmly believe that this three-prong approach is going to endure the test of time because it is good, and because it is balanced.

Within that mandate, within that three-prong mandate I am an advocate of change, functioning under the rule of law. As we face the regulatory challenges that are sure to be posed by the certification and licensing of new designs, a series of all too familiar requirements will have to be met, regardless of the licensing path chosen. And this, you know them well:

- Public involvement
- Safety reviews
- Independent ACRS review
- Environmental review
- Public hearings
- NRC oversight

I am convinced, and I have white hairs to prove it, by practical experience that the present pathway for potential licensing success of certified or certifiable new reactor applications is Part 52, and I will tell you why.

First, it exists; and this is not the minor issue the fact that it's here and available, and is in the books.

Second, it contains the requirements for assurance of safety and the processes for their implementation.

And lastly, it can be upgraded to meet technological advances that require new licensing paths, without compromising safety.

Windows of opportunity can be opened, yet the price is always the same: Reasonable assurance of public health and safety. A new technology, with different design basis phenomenology. In other words, things like single phase coolant that we are talking about, could present the need for a different pathway. Yet, it would have to face the same requirements listed above. What could be different is the manner in which some of these requirements are addressed. There is definitely room for innovation and improvement, within the safety envelope that has to be provided for assurance of public health and safety.

I am also convinced that the NRC and all stakeholders need to apply a common criteria to the tasks at hand. Every success path, whatever direction you're coming, however you define success should follow this simple criteria: Every path, every step has to be disciplined, meaningful and scrutable.

Allow me to consider widely different roles.

The NRC has the statutory responsibility for conducting licensing and regulation in a predictable, fair, equitable and efficient manner to ensure safety. Every step of these processes of the licensing and the oversight has to be disciplined, has to be meaningful and has to be scrutable.

Applicants need to satisfy the technical, financial, and marketplace requirements, and meet the NRC and other regulatory requirements. Every step that is taken has to be disciplined, meaningful and scrutable.

I have no doubt that there will be objections and opposition and the law of the land will respect them and give them full consideration. The objections will have to be disciplined, meaningful and scrutable.

These common criteria are necessary, but they are not sufficient as you all know.It is indispensable that what we have learned, and it is much what we have learned, be incorporated into the science, engineering and technology supporting any new reactors; they have to be as good as the state-of-the-art permits.

Let me take a chance and depart from my statement. There is no doubt that we're all creative, we're all innovative, we like to do things better. But this is the time that will not take too many errors. This is the time in which we need to be patient and we need to exercise what we know in a disciplined manner to make sure that errors are avoided. Okay?

Things that we do will have to be upscale. And everything applicants do will have to be on budget. Anything else is not good enough.

Whatever we do with the technology, we have to match it with the regulatory processes. They have to be as good as the state-of-the-art permits. I happen to believe that risk-information can be a contributor to disciplined, meaningful and scrutable processes and to the underlying science and technology.

Someone once wrote a phrase framing how to achieve high performance expectations, which is where we are right now, and it may be appropriate then to just pause a moment and think that a lot of us need to promise to think only the best, to work only for the best, and to expect only the best.

Thank you very much.

DR. KRESS: At this time I think we are collecting some written questions. Is that true, Mike?

MR. MARKLEY: We're working on it, Dr. Kress. At this time we don't have any.

I think we could entertain oral questions from the audience at this time while collecting these written ones. They don't have to be written. So, if anyone has a burning question they'd like to ask Commissioner Diaz, please feel free to do so. Use this microphone or this one over here, please.

Please identify yourself.

MR. QUINN: Commissioner Diaz, it's Ted Quinn.

The question I have that the combined operating license part of Part 52 is unproven. We haven't run through that yet, as well as early plant siting. Can you define how the Commission can help the staff to provide, to make this a more stable process as we go through it so that the financial community will help us to get these through?

COMMISSIONER DIAZ: It's a very good point. We have it, it's there. We've been looking at it for some time, but it's not been tested. The issue is how do we make sure that it works the way it should be, effectively and efficiently.

I think we learned a lot at the license renewal process. And I believe that what I have learned the last few years is that Commission involvement is very, very, very, very necessary in this step. That we cannot let a lot of these things go a lot of the time to perfection.

I will use one of the first phrases I used in a meeting down there that the enemy of the good is the better and the enemy of the better is the best. And, therefore, we are going to have to be in very close contact with the staff. And I believe the Commission will actually take an important role in making sure that the processes are timely.

In this respect what we have done is many other things the last 3½ years, is we have maintained our doors open. We have allowed stakeholders from all different areas to come and visit and let us sometimes close this little gap that exists, it is vital information to us how stakeholders, whether they're industry or there are other, you know, groups that have an interest in the proceedings, let us know how things are going. And that has worked very well. It keeps the Commission informed early. Sometimes, you know, the staff protects the Commission and shields us from knowing the little problems that are happening. And sometimes that is fine. It's really, you know, I appreciate it. But there are times in which we need to know ahead of time.

And I think this process should be very similar as far as the Commission is -- really on top of it all the time.

DR. KRESS: Other questions? Do the members of the ACRS wish to ask a question of Commissioner Diaz.

DR. POWERS: Dr. Kress, I'd like to phase the issue of nuclear waste, which comes up repeatedly in connection with all the discussions of nuclear power, especially as we go to looking at maybe an increased use of nuclear power.

Are we making any progress on this nuclear waste issue? Is there something that the NRC can do or is this totally in the hands of the Department of Energy?

COMMISSIONER DIAZ: I think the NRC has done as much as it can do. We have engaged in the process all the way. And we have tried to make sure that everybody understands that we believe there is the science and technology that offers a better pathway that ensures public health and safety.

I think the decisions right now are practically at final stages. I cannot comment on them. I think that, you know, we are going to do what we do best; we're going to take whatever the country decides in the Congress of the United States and the President, and EPA and we're going to work with them. We're going to try to make it, you know, an inspective process. And that is what we do best.

You know, whatever is coming down, we're going to use it. And if an application is submitted, we're going to try to license working through a process, and that process if not assured. We're going to have to look at it every step of the way. And, hopefully, you know, the Department of Energy will do a good job and will allow us to do a provision of it. And we will like to ensure that the process is open to the public. We need to make sure that this is disciplined, meaningful and scrutable.

DR. POWERS: Not to get off point or anything.

DR. KRESS: I have a question, Mr. Diaz. With some of the new reactor concepts, I see one of the hard places regulatory challenges to be in the area of defense and death, which is you know a general guiding principle for regulation.

Do you think the concept of defense and death is sufficiently rigorously defined to quiet some of the newer reactor concepts or will we have to rethink what we think defense and death is?

COMMISSIONER DIAZ: This is a setup.

DR. KRESS: I'm sorry about that.

COMMISSIONER DIAZ: I think, you know,

those of us who work in reactor science know what defense and death really is and what are its limitations. I think we have actually reached the limitations of defense and death, and that it is time to move forward and use it in the best possible manner, but complimented with everything else that we can to make sure that we don't make cumbersome, you know, design requirements or cumbersome regulatory requirements. And I go back to that definition, the end of the definition and risk-informed regulation, which avoids unreasonable burden. And that's what we have to do, because the burden eventually will be in the top, you know. The logical thing the burden will be on whoever it is, the burden is eventually in the people of the United States.

So, I believe that we need to relook and resharpen our focus. I know the ACRS has been working on this, and I share a lot of your views.

DR. APOSTOLAKIS: Well, this is related I think to the use of risk-information in licensing and regulations. And we hear that the agency may, in fact, receive license application in the very near future. Do you believe, Commissioner, that the regulatory system is ready to review such a license application or does it require some fundamental changes, which will take time, of course?

COMMISSIONER DIAZ: This is setup number two.

Knowing we think we're ready, but we count on the ACRS to make us ready.

DR. APOSTOLAKIS: I am speechless.

COMMISSIONER DIAZ: We will work hard at it. And you guys are going to need to come and pitch in. I think everybody is getting their attention focused on how can we move in this area, what is that we know sufficiently that will provide within that envelop that I keep referring to provide the protection of all the processes. And I think there are hard decisions to be made, and I'm not kidding that we can revoke our problems.

DR. KRESS: Any other questions?

Mike, are there written questions that we could entertain?

MR. MARKLEY: No, we have no written questions at this time.

DR. KRESS: Okay. With that, I'd like to personally thank once again Commissioner Diaz for an excellent keynote speak.

As a matter of fact, we're a little bit ahead of time. But at this time I would like to go ahead with our scheduled break. Let's keep it to about 20 minutes, and return about 10:00.

(Whereupon, at 9:30 a.m. a recess until 10:01 a.m..

DR. KRESS: Let's get started again, please.

Based on our experience so far, I'm going to go out on a limb and change the mode of operation just a little and do away with the cards as an experiment and allow questions to be entertained after each presenter makes his presentation, so it'll be fresh in your mind what you just heard, and you can give all the questions at each of the microphones. So we'll try that and see if it works better. If it doesn't work, we'll go back to the cards.

Now we'll turn to the spot on the agenda in which we will hear extensively from DOE for Gen IV and Gen III. And the first DOE speaker is listed as Mr. Magwood, so I'll turn the floor over.

MR. MAGWOOD: Good morning.

Are you sure you can hear me? Are you sure you want to hear me?

Well, good morning. I'm Bill Magwood, I'm Director of DOE's Office of Nuclear Energy, Science and Technology.

Thank you for scheduling a break in a time that I was able to go to the restroom. I really appreciate that. It will make the presentation a little bit longer, but that's a good thing or a bad thing; depends on what you think about what we have to say.

First, in the way of introduction, and I apologize. I'm a little behind on what the viewgraphs look like. I know that I saw these about a week ago, but since I've been out of town and then here I am. So, I'll be sort of looking at these a little bit fresh, I think.

Of course, I just got paged, and hopefully it's not the Secretary's office. Okay. That can wait.

Well, first, let me give you a little of background about the Office of Nuclear Energy, Science and Technology. Our program, as you know, has been around since the beginning of the Atomic Energy Commission back in the late 50s. And we're basically the same program that's existed throughout the '60s, '70s and '80s; the names have changed, the faces have changed but basically we're the Nuclear R&D program of the federal government. We're responsible for advanced reactor technology development, fuel cycle technology, medical isotopes, space reactors; the whole range of federal involvement in nuclear R&D.

And over the last decade we've seen our activities plummet to a really, quite frankly, embarrassingly low level. Actually, in 1998 our budget actually for nuclear energy research development and development actually hit zero. And it was kind of an embarrassing situation for us. We had people coming in from Korea and Japan asking what's going on, what does this mean. And it was very difficult to explain to them well, you know, it's kind of like being between jobs. You know, we're between programs right now.

What we were doing during 1998, though, was not sitting on our hands. What we were doing was trying to understand what DOE's rule in nuclear R&D really ought to be in the long term future.

In the past, DOE's program is characterized largely by the creation of demonstration reactors, very large, very expensive programs like the integral fast reactor program, defense reactor project, things like that. It was pretty clear that we weren't going to be seeing hundreds of millions of dollars anytime soon, so we were going to have to find a smarter, more efficient way to do nuclear research.

What we came up with was a variety of things. First, we recognized that we were going to have to base our program much more on international cooperation than in the past. In the past, DOE always had been a large monolith to which other people tagged on. The Japanese worked with us, the French worked with us, other people worked with us, but DOE was much more self-reliant and was more interested in assimilating technology than it was in bringing technology in. That had to change because of the resource issue.

The other thing that we recognized was we're going to have to bring in much more outside perspective, much more of an outside peer review approach. So that ultimately became our nuclear energy research initiative, the NERI program which some of you are familiar with.

But we also recognized that it was going to require more of a cooperation with our stakeholders such as NRC, which we're now working more closely with than ever before, the industry, our Nuclear Energy Compensation Program, entities like that. And also focusing more on infrastructure, which is something I think you're going to hear a little bit more about over the course of the morning.

And one of the parts of research we have been working on a great deal has been our university research reactors and education program.

So our program over the last several years has really changed dramatically from what it was, say, five or ten years ago. In fact, I think a lot of people looking at the program from that perspective will probably be very surprised to see (1) how much less money we have, but (2) but in the way we operate, how different it is.

What we're going to be focusing on today is what is the future for the nuclear research program both in the federal government, but also more broadly talk about that.

See the next slide, please.

One of the primary focuses that we've enjoying over the last year or so has been Generation IV systems. You're going to hear largely about that I think this morning. I think that's the focus of this presentation, and I'm going to explain to you what that is.

Now, this proves this I haven't seen this because I would never be giving you a talk with little mailboxes on it. And I think these are pencils. They're either pencils or ballistic missiles, I'm not really sure which. Since we're a civilian program, I'm going to assume they're pencils.

Generation IV energy systems are systems that can be deployed by 2030. So, I'm going to actually skip this chart and go to the next chart. I think it's much more descriptive. Why don't you give me the next chart. I think I'm right. Yes, okay, much better.

Here's how we got to Generation IV. Looking back in the past we had this first generation of systems, such as the Dresden plant, the Shippingport plant, the very first ventures in the commercial scale of nuclear power production. These lead to the most successful energy programs, I think, in the history of the federal government in some ways; today's nuclear power plants, Generation II nuclear power plants. And these make up most of the plants in operation in the world today. These are all the LWRs in the United States and most of the LWRs throughout the world, as you know, which are based on U.S. technology.

The very successful program, obviously, has not been entirely successful otherwise we would still be building them, but nevertheless when you look at the fact that 20 percent of our electricity comes from these power plants, it's hard to say it's been less than successful.

We did, however, need to do some improvements. And as we learn more about how nuclear power plants operate, we were able to design the next generation of plants, Generation III plants, the advanced light water reactors and the advanced BWR, the System 80+, the AP600 that generation of nuclear power plants. And this is also, I think, on the verge of being very successful. They're already building some of these plants overseas, obviously in Japan, Taiwan, but also parts of the technology are beginning to disseminate elsewhere in Korea.

So when we start to think about what the future ought to be, the question really was where do we go from here? Where do we go from the Generation III reactors? Well, there's two steps. There's a near-term step which we either consider to be just a follow on to Generation III or we actually give a little bit of an extra push and call it Generation III+. And then we speak of Generation III+ we're usually talking about slight enhancements to the existing state-of-the-art nuclear power plants.

For example, the AP1000 versus the AP600 is considered to be a Generation III+. There are others. I'll try not to get too specific about that because you get in arguments about what's Generation III+ versus Generation IV, and it's a pointless exercise.

But part of our program is focused on trying to move to this next step, deployment of the state-of-the-art technologies possibly with some enhancements in technology, Generation III and III+. But the more exciting part of our program, I think, is looking at Generation IV reactors. Generation IV, quite frankly, is just characterized in very simple ways: What comes next?

Now, we do have some more of a definition then at this point, and I'll talk about that.

Let's go to the next slide.

What we've done so far is the Subcommittee of our Nuclear Energy Research Advisory (NERAC) to establish specific technology goals regarding these future reactors. I think we're going to get some more detail about this. But when NERAC brought this group together in just October 2000, it's been a very, vary active group ever since. Their job is to help us develop a technology roadmap for Generation IV nuclear power plants.

This technology roadmap is going to be

lead by a subcommittee of NERAC, which is composed of people from U.S. industry, academia. And now there are laboratory people helping them, but really the core of the group is made up of academia and is co-chaired by Neil Todreas at MIT and Sal Levy of GE. And they provide a lot of leadership in trying to move this process forward.

Let's take a look at the new viewgraph. Okay. That helps.

The NERAC Subcommittee had as its first action, and we gave it a very, very short term time to do this, to draft these technology goals for the direction for nuclear power plants. As I say, you're going to hear more about this, but to give you an example the technology goal for Generation IV is, one of the goals, and it's my personal favorite states that there should be no operating or accident condition that required an off-site response to an emergency. And that means eliminating the concern of the public, basically, that the operation of nuclear power plant would effect their lives. Whatever happens to the plant stays on site. It becomes an on site issue, but would not have an impact off site. That's a technology goal.

Now, we had a lot of discussion about that as a goal, obviously, because a lot of people say "Well, you know, you can't ever promise it will never be outside event. But, you know, we took a philosophy that if it's a technology goal, you work towards that, you see how close you get, you see where the technology leads you. So, that's part of the process and you'll hear more about this.

More to the point, these technology goals aren't an end into themselves. They're used to drive an R&D program. And what NERAC's next goal, and this is where we are right now, was to take those technology goals and formulate an R&D program based on them. And how are we doing that?

Now, as you're about to hear what we've done is we've reached out to a very, very large group of people out to the international community. We have -- let's skip over to the next one. I'm not going to go on all these viewgraphs.

We've brought together something called the Generation IV International Forum, which I expect to be official by the end of this month. We're working with eight other countries; Argentina, Brazil, Canada, France, Japan, South Africa, South Korea and the United Kingdom. We're working with these countries to try to formulate what concepts, what technologies can meet these very, very high level technology goals that were set by NERAC. So the Generation IV International Forum has worked with us to identify approximately a 100 people all over the world, most are in the U.S. but there's about 40 percent or so of them are actually international from these various countries, but also including people from the IAEA, people from the OECD/Nuclear Energy Agency and people from the European Commission to help look at all of the various concepts that are out there, all the ideas that come from our NERI program, for example, and put them through a very, very extensive rigorous progress with the goal of arriving at a small number of technology concepts about which the international community including the U.S. can rally about.

Our goal is that by the end of -- and I don't know if the next one's got names or not, we'll take a look. No, we'll skip that one. Okay, that'll do.

Our goal -- work backwards on this chart. Our goal is by September '02 to be in a position to tell you what handful of concepts, we're aiming for maybe about a half a dozen concepts, hopefully less. But a half dozen is probably the most we can stand.

What small number of concepts would be acceptable under the Generation IV technology goals and about which you can write specific R&D plans.

Now NERAC's job will be to identify those concepts and then write the R&D plans, and that will constitute the technology roadmap.

This has already been a very ambitious project. In fact, I think a lot of people when they first heard about what we were going to try to do, thought we would never be able to get this far. We'd never be able to get so many countries to agree on a process that would narrow so many concepts down over such a short period of time. But so far, we've been very successful.

We've been able to keep the Generation IV International Forum together as a unit. In fact, rather than having it fly apart, it's actually become much more close knit, much more integrated than it was when we started off. And we've actually agreed to a charter that each of the countries will sign by the end of this month. So we're very excited about that.

Now, in the nearer term, obviously, because of the energy concerns we're experiencing in this country, we do have to think about what can be done this decade. Let me speak about the dates for a moment.

One of the things that I said earlier was that Generation IV concepts need to be deployable by 2030. That's not to say that if you can arrive at a Generation IV concept it can be deployed next year that we shouldn't go forward with it. But the limit, the outer limit is 2030. That means that we don't have a situation where we're competing with fusion to be the long lead technology for the Star Trek generation, okay? We want to make sure that where we talk about real technologies things can be engineered now and try to arrive as -- projects can be demonstrated within a very, very reasonable of time. So 2030 is the outer limit.

In the case of the near-term plans, the Generation III+ technologies for example, we're focused on things that can be done in about 2010. Now, we're a little softer with that date because there may be some things that are more arrival in 2012, say, versus 2010. So we're a little squashier about that. About 2010 is the time frame we want to see these new near-term technologies deployable.

Our goal is to make sure that we can identify the technologies, the technology programs, the institutional barriers that need to be resolved in time to enable these plants to be built in the U.S. by 2010. And we are working very closely with the industry on this. We have a task force under the NERAC Subcommittee that's chaired, I believe, by Lou Long of Southern Company. Is that correct? I think it's Lou Long. Is there a co-chair? Tony McConnell. Okay. And these folks are helping us on an industry basis. In fact we've just come out with a CBD notice, I believe and a Federal Register notice to solicit input from the industry to identify what those institutional barriers are, technology barriers are and to put forward a plan to try to resolve all those barriers in a time frame consistent with our 2010 date.

This one is a little ahead of the Generation IV side. We expect to have that more completed this September. And actually, most of it is already done. We're really just about there. There's a lot of things that need to be refined, but the larger ideas are really in place. And by next year, September '02 we'll have the entire Generation IV roadmap.

So that's what we're pursuing at this point. It's a very, as I said, ambitious activity. It involves a huge number of people.

You're going to hear about how we've organized this. Who's giving that? Is that you, Rob? Rob is going to describe how we've organized this. It looks like a spaghetti nightmare, but trust me; it makes sense, it works.

Is that the last viewgraph? Okay.

With that, let me just summarize by saying that the U.S. DOE has been gratified with the response we've gotten from the international community and from the industry, and from NRC and everyone else that's worked with us on this. It's been a very important activity.

And excuse me, John, for turning my back to you. John here is helping us a lot with this, so he's very familiar with what we're doing. And what we're trying to do now is to bring all this home. We've organized it, we've got participation from everybody that we think we need participation from. We're going to reach out a little bit more to stakeholders over the next year, I think. But this is really working and we're going to keep the work, and we're looking forward to your thoughts as we go forward.

And I appreciate the opportunity to talk to you today, and I'd be happy to answer any questions.

DR. KRESS: We'll entertain questions from the audience or from the members, either one.

DR. APOSTOLAKIS: Dr. Magwood,if you had to give us the two most important regulatory challenges for meeting all these wonderful initiatives, what would they be?

MR. MAGWOOD: That's a good question. I think that the most -- I think I'll answer the question a little more generic.

I think that it's extremely important the NRC move as close to performance based risk-informed regulation as possible. Because these technologies are dissimilar in so many ways, and you're already starting to see it. There's already a large discussion going forward about the pebble bed reactor versus light water reactor technology and how you license those.

The only way to do that successful with these different concepts floating around out there is to move to a technology independent regulatory approach. And unless you do that, you're going to inhibit the development of these new technologies because people will not have the confidence that NRC can respond quickly enough to regulate these technologies.

I know there's a lot of concern about how long it's going to take to get regulations for the pebble bed reactor. And we're working with General Atomics at DOE with the development of their system, and that presents similar challenges. So I think that that larger issue is the one you have to deal with.

In the nearer term I think it's really more a job of demonstrating the pieces are already out there. But even as we look at these newer technologies coming in before now, they present issues, many that you are already very familiar with.

So I would say that pushing as fast as possible towards a new regulatory regime that will support new technologies in the next century is really going to be -- should be a high priority.

DR. APOSTOLAKIS: In the next century?

MR. MAGWOOD: Well, in this century. I'm sorry, I fell back. In this century. I'm sorry I fell back.

DR. APOSTOLAKIS: Speaking of long term.

MR. MAGWOOD: Well, you know, it's interesting one of the things I mentioned to the international community -- I'll just sort of digress for a moment.

One of the things that was very challenging about pulling everyone into this early on was that unlike the U.S., other countries know where they want to be in 20 or 30 years. You know, the Japanese have very specific plans of where they'd like to be over the next 30 years. So, you know, getting countries like Japan and France that know where they want to go to agree to a process like this was challenging, to say the least. But I think that the fact that we're open-minded about where the answers come out gives them confidence that, you know, that their ideas may well fit into whatever comes out of the end of this.

Also just for your gratification, one of the things that we were very pleased about with the international community was that they made very clear that they believe that the U.S. was the only country that pulled this together and that without the U.S. in the middle of this bringing all these other countries together, that there's no way you would ever be able to arrive at what they believe, what many countries believe the future really has in store for us which is more common reactor designs international.

And so doing this on an international basis is absolutely essential. Having the U.S. go off and do this on its own would be a waste of everybody's time and money. And so, you know, we've been very pleased with the international response. But I think that in the future we're going to see that the steps that you take and the steps the NRC takes towards regulating these new technologies will really set the tone for the rest of the world. So it's very important that we go about that in the right way.

DR. APOSTOLAKIS: Is NERAC going to give us any ideas as to how we can have this regulatory system that will not be technology specific?

MR. MAGWOOD: We've talked about whether to get involved in that. And I think the main conclusion was that we shouldn't because for two reasons. First, it really is something that NRC needs to deal with. You know, it's something that the NRC has more experience with than we do and very few of the people that we've been working with are very comfortable going off to give NRC a lot of specific advice.

And secondly, quite frankly, the time that it would take to do that probably means that it would require a different project than what we're currently doing. That's not to say that we wouldn't have a follow on step where we would try to move in that direction. But for the near-term, I don't think there's anything that NERAC's is going to add to where NRC is going. We just need to encourage them to move forward quickly with what they're doing.

In a longer term, it may make sense to bring another group together to look at those long term regulatory issues.

DR. APOSTOLAKIS: Thank you.

DR. KRESS: Other questions?

DR. POWERS: Well, it seems to me that if you're going to encourage people to move to a performance based regulatory system, that must mean surely you're looking at performance indicators for these new generation? Is that the case?

MR. MAGWOOD: I think the answer to that is yes. If you look at our technology goals, and I think you're going to get a rundown of that. Is that going to be part of your presentation? You're going to get a rundown of that.

You'll see a very high level version of what those performance goals are. On a regulatory space, you're talking about safety. You'll see some indications where we think things should go, but not to the level of detail because these technology goals are very, very high level. You're not going to see a low level of detail, but you will see an overall vision.

DR. POWERS: High level and not very specific doesn't make for useful regulation.

MR. MAGWOOD: That's a --

DR. POWERS: At some point somebody has to come down and say if you want a performance based system, you got to have performance indicators that are used and monitored.

MR. MAGWOOD: But what I would say is that what -- what we can provide as part of our process, all these high level goals. These high level goals will very quickly, depending on which technology concept you're looking at, provide some framework that NRC or someone else could use to begin to design a regulatory approach. It's not really -- again, it wasn't our intent to try to set this up to defeat the NRC process. You know we clearly could to do that, but that's not the intent here.

Our intent was to drive an R&D program, not separate or instruct. Now, I'm willing to hear some advice. You're an advisory group, so give us some advice. We're part of the program.

If you think that we should follow on this activity with an activity focused more to the regulatory side, you know, I would be very happy to work with Ashook and his group to try to put together an appropriate advisory group that will do that. Because I think it's important that it be done. And if takes DOE involvement to get it started, I'm happy to do that. But this isn't the activity to do it, that's my biggest point.

DR. KRESS: Okay. Seeing no other -- oh, there's one. Okay. Please identify yourself.

MR. LYMAN: Ed Lyman from the Nuclear Control Institute.

Bill, I think there is public issues that really have to be thought about before large expansion in DOE's research budget has to be contemplated. Because these days you have to really worry about whether what looks like government subsidization of one energy technology over another, how that will be perceived, especially by small scale generators using other competitive fossil fuel technology and stuff. And in a deregulated environment that's going to be a greater concern.

So, I was encouraged when these reports of a task force on near-term deployment that recently reported to NERAC discussed a cost sharing program with industry for near-term deployment. I was wondering if industry had actually made any firm commitments in that regard, since would be a positive step since I don't think they've put any money down so far in these initiatives?

MR. MAGWOOD: First, it's important to clarify, and I think you raised a good point. There's two things really important to clarify.

First, in general, you know our office is not in the business of corporate welfare. We're not here to make technologies marketable that wouldn't otherwise be marketable, you wouldn't otherwise compete on it. In fact, our goals, and you'll hear about it, for our Generation IV have a lot of built into them about the need to be economically competitive. That's a hallmark of what we're trying to do.

And let me say for the record that there should not be a new nuclear power plant that's not economically competitive in this country. It shouldn't be built because we're not going to subsidize it and if industry is not willing to go off and do it because they can make money, it shouldn't happen. It shouldn't be done.

Now, regarding the specific point you raised, I think that where we are right now -- well, first it's important to recognize that this is a NERAC advisory group, so we're not at the point where we're making commitments on a policy basis on behalf of the industry. We have asked certain experts in industry along with academia and working with our national laboratories to come together and make recommendations. These recommendations will flow up through the NERAC process and if it comes out the other side, NERAC will make a recommendation to DOE that we should go pursue a program in that vein.

But at that stage, if that were to happen, we would be in a position to approach the industry and say "Okay, your people were on this panel, here's the recommendation that they made, Mr. CEO do you want to buy into this?" And if they don't want to buy into it, we don't have to do it. But, you know, it's a recommendation. It's not a commitment on anyone's part, especially ours.

You know, with my budget I couldn't commit to anything they recommended at this point. So, it's really a recommendation for the future.

The question we asked was if we were going to solve these problems, how would we go about it? And that's what these recommendations gives us. It gives us a way of solving the problems.

It doesn't mean that we have to do it. It doesn't mean the industry has to do it, but it gives us a methodology.

So the answer to your question is no, no one's made any commitments, nor would it be appropriate to at this point in time.

DR. KRESS: Okay. With that, let's move on to the next speaker. But before we do, the question that George asked about what you may think is the two or three most challenging, most difficult regulatory challenges, each speaker might want to consider that as a generic question and feel free to volunteer an answer to it without it being asked.

The other item is, I don't have any introductory information or remarks to make about each speaker, so as was obvious with Mr. Magwood, so would each speaker please introduce himself when he gets to it.

So, with that, I'll turn it over to the next speaker.

MR. VERSLUIS: Good morning, ladies and gentlemen. My name is Rob Versluis. I'm the project manager for the Generation IV roadmap.

Now that Bill Magwood has given you an overview of Generation IV process, I'd like to focus on the long term and in my talk summarize the roadmap process and products that we expect.

The first objective of the Generation IV roadmap is to identify and evaluate the most promising advanced nuclear energy concepts. And we have three years to do this. We started in October of last year. And expect to be finished September next year.

An important role is played by the advisory group. Bill has already mentioned it, the NERAC Subcommittee. Actually, it's better known as GRNS, Generation IV Roadmap NERAC Subcommittee, although that's not actually their official name.

They are very much working with us and directing or advising us on the direction for the roadmap work.

The actual work is being done by several working groups. The staff consists of about 50 U.S. experts, about evenly divided between industry, labs and academia. And recently we have received 40 volunteer experts from the GIF countries. That is a very respectable participation from the international community.

The second objective, and really the product we are looking for from the roadmap, is the R&D plan to support future commercialization of the best concepts. And this completed roadmap will do two things.

It will identify and evaluate concepts. That is we intend to make a good start in calling out the most promising concepts.

And secondly, it will formulate the R&D tasks for the best concepts; that is to find a sequencing and preliminary costs of the R&D tasks required for commercialization.

We recognize that even after two years of hard study there will be many questions left about the viability of the most promising concepts. The R&D defined by the roadmap is intended to both answer questions of viability and show the real performance capabilities of the selected concept.

And, of course, the final nuclear energy system selection will involve industry and the marketplace.

Like any planning activity we start with formulating goals, which was actually done by GRNS. And these goals strive to reflect energy needs for mid-century, and we actually have the date of 2030 on it, but obviously if these plans are going to be built and deployed, they're going to be run for many years.

And so we've tried to envision mid-century with its population growth, its growth in standard of living, its world economy and its need for other energy projects besides electricity, such as clean water. This is reflected in the appearance of sustainability goals alongside safety and economic goals. And let me quickly take you through the goals.

In fact, this is all I'm going to show about them, because Neal Todreas is tomorrow and his talk will go in more detail about the goals.

There are three sustainability goals. One that is concerned with the resource inputs, that is fuel, materials, energy inputs in nuclear energy system. Second with waste outputs. Waste streams of all sorts. And the third is proliferation resistance or nonproliferation.

Then there are three safety and reliability goals. One on excellence, one on core damage and one on emergency response.

And finally, there are two economics goals: Life cycle cost and risk to capital.

These goals, in fact, provide the basis for evaluating the technologies.

What do we really mean with a Generation IV system? It is an entire energy production system, including the nuclear fuel cycle front and back end, the nuclear reactor, the power conversion equipment and its connection to the distribution system. It must recognize various energy products, electricity, hydrogen, fresh water, process heat, district heat, propulsion. And also the infrastructure for manufacture and deployment of the plant.

Furthermore, we limit to systems that are likely to be commercially viable by 2030. And also the primary energy generators in the system must be based on critical fission reactors. That means that subcritical systems, accelerator driven system, would have a secondary role in the fuel cycle, but the primary energy generators should be critical systems.

The next slide shows the roadmap organization. The central part shows the working groups and the integrating functions. And I'll come back to that in a minute.

On the left it shows the advisory committee relating, of course, to DOE-NE in the roadmap. And also the technical community, the left bottom, from which both the GRNS and the roadmap draw its resources; that is its staff. Further resources are drawn then from the GIF countries on the right hand side.

DOE-NE manages the program. This is where

Tom Miller, who will speak next, and I sit. And underneath -- actually it shows the near-term deployment group in orange underneath DOE-NE.

Then the next group that it shows is the roadmap integration team, RIT. And look at those abbreviations because they will come back in later slides.

The RIT does what it says, it manages the roadmap process and does the final integrating of the roadmap itself. It is composed of two senior managers from Argonne National Laboratory, two from Idaho National Energy Environmental Laboratory and myself.

The next group shown is the evaluation methods group, and this is the group that is charged with defining the criteria and metrics by which they evaluate the concepts on their ability to meet the Generation IV goals. They actually start with the goals and they translate them into criteria and metrics, which is a long process, actually.

The actual work of identifying, describing and evaluating the concepts is spread over the four groups shown in the middle bottom. They are organized by a coolant technology somewhat arbitrarily, but it lines well up with people's expertise. And so there's a group on water coolant, on gas, on liquid metals and then there is none of the above where the non-classical concepts are being evaluated and described.

In addition, we envision forming technology crosscut groups. And that group, you know, standing vertically there on the right is an example of such a group. It draws actually from the same people, from the same working groups, but it lines up the experts in a certain technological area and it puts them together to get a crosscut perspective over all the concepts. And you can envision crosscut groups like fuel cycles, risk and safety, materials, power conversion and others, perhaps.

The fuel cycle group was formed early to deal with the common fuel cycle issues for all of the concepts, and also to define the fuel cycle framework for the energy systems. And they have defined four generic fuel cycles: The once through fuel cycle; a single plutonium recycle; multiple plutonium recycle; and a full actinide recycle. And they describe those and provide a framework for the other groups to work within.

They also analyze energy demand scenarios. They're not making any new ones, they use the World Energy Council's scenarios and they pick the three scenarios of those to drive the thinking about resources and build up.

This shows a high level overview of the schedule for producing the roadmap.

Phase 1, the initial work is getting organized and staffed. Phase II, the needs assessment looks at the concepts and identifies the technology gaps. Phase III, the response development defines the needed R&D. And Phase IV, the implementation planning actually finalizes the roadmap. And the slide also shows the time frame when the activities take place and about the product of the phases.

Let's step through the tasks. First the goals and plans. First, we drive the technology goals based on industry needs, and that has been done by the GRNS and it's been reviewed and with some comments endorsed by GIF. And it's captured in a technology goals document.

Next, plan the activity. We published the Roadmap Development Guide for use by the roadmap participants that describes the overall approach, and the working groups have been convened including international participation.

The first time we convened all the working groups was in February in Denver, and it only included the U.S. participants and we described to them the approach of the roadmap, the various responsibilities of the groups and what's expected from them.

Then again, in Chicago we had the second joint meeting of all the working groups. That was last month in May. And that included all the international participants. So we had, again, a familiarization stage, but they also actually were there to do work.

Then next we determine how to measure the concepts against the goals. We developed a criteria and metrics for each goal and then continue on to develop the evaluation methodology. This is conducted by the evaluations methods group with the feedback and assistance from the roadmap integration team and the GRNS.

This slide discusses how we're dealing with the concepts. First, identify the concepts for evaluation. We have now about 100 concepts and they are drawn from the U.S. and a broad international base. And they are now adopted by the technical working groups and synthesized. When I say synthesized, I mean that in many cases a concept was not complete and needed to be synthesized with other fuel cycle systems or parts of the fuel cycle system.

The concepts are also being grouped into sets if they show sufficient similarity to increase the productivity. To conceive a 100 concepts we're going to have to package them up a little bit, and I will talk about that later this morning.

Then the most promising concepts need to be detailed better, so that's the next step. And the TWGs are now interacting with the concept teams and the advocates to get more information. They actively study and compare the underlying technology. And they are now getting ready for what's basically two screening stages. The first screening is called screening for potential and the EMG has developed criteria, qualitative criteria for that. That initial screening is pretty lenient and it's because it's been based on limited information and we really don't want to throw too many things out at this point.

And then a later evaluation next year will be done next year.

Let me clarify what I mean with concept and concept sets. Concept, as we use the word, is a technical approach for a Generation IV system with enough detail to allow evaluation against the goals, but broad enough to allow for optional features and trades. And a concept set is a logical grouping of concepts that are similar enough to allow their common evaluation.

In the second year we evaluate and assemble. We evaluate the most viable concepts, we compare the concept performance to the goals, and that is really the finally screening. And then we identify the technology gaps. And in this work the TWGs, the technical working groups have the lead. And, of course, the RIT and the EMG looks over their shoulders and make sure that the criteria are being applied consistently.

DOE has the approval function here, and we will seek the endorsement of GIF.

And then the final stage is assemble the roadmap to support the most promising concept. That means identifying the R&D needed to close the gaps that have been identified in areas of crosscutting technology, assemble a program plan with recommended phases. And that will then contain the sequencing and estimated costs of the R&D tasks. And the groups write here their final reports. The RIT takes the input and integrates this into the roadmap. Again, the DOE has an approval function and will seek the endorsement of GIF.

This slide is another cut at the schedule from the perspective of the screening and down selection. A lot of work is actually going into taking these goals, translating them into criteria and metrics and applying them in these screenings. And, as you see, the screening for potential is coming up in July, 2001. Then there is an eight to nine month period before we do the final screening, which will be more strict and based on further developed and have more sophisticated criteria and perhaps in some cases, quantitive metrics.

After the roadmap completion, planning becomes more uncertain as you go further into the future because it involves things such as government policy, budget, market, et cetera. But we have indicated there sort of a base scenario that includes the terms of viability and performance R&D. And we have made provision for further down selection using more quantitive metrics to show if the potential can really be realized.

At some point we envision to hand off to industry based on their reading of the markets.

That concludes my presentation.

DR. KRESS: Thank you. Questions anyone?

DR. POWERS: Yes, I have a question that comes to mind when I see these plans for Generation IV reactors. My good friends at the Nuclear Energy

Institute regularly provide me metrics on the performance of the current generation of plants in a variety of areas, including resources, safety and economics. And they show excellent performance, just outstanding performance in the last ten years going along.

In all this roadmapping exercise, do you carry along some representative of the current generation plants as a comparison so you can see if you're really going to accomplish anything with these new plants?

MR. VERSLUIS: Well, it's a good question because the initial screenings are really not much more than comparing in a number of different areas with the Generation III technology. So, they are qualitative comparisons, and that's how we approach it, is comparing it with the Generation III technology.

DR. POWERS: See, now the Generation III is like the --

MR. VERSLUIS: The fast light water reactor.

DR. POWERS: The 600 or the 80+ or something like that?

MR. VERSLUIS: Yes.

DR. POWERS: We don't have a whole lot of performance and data on those Generation III plants the way we do with the existing plants?

MR. VERSLUIS: We think at this point with the amount of data that we have on the various concepts, there is no need to be very, very precise about these things. What the schedule, the last slide really showed is that we need to do a certain amount of viability research where we get a better handle on how to measure, how we can measure the various indicators before we can do a more sophisticated screening.

DR. GARRICK: Rob, it might be important to point out, too, that GRNS has put a lot of emphasis on the total energy system concept, and that has kind of evolved. When we first got together, that wasn't so much an emphasis. And when you think about performance indicators, you've also got to think about the scope that we're addressing this time, namely the total energy system.

So, it would seem that if we're going to go in the direction of performance indicators that are compatible with risk-informed performance based regulatory practice, we'll be talking about probably a different structure and at least a more range of indicators that we've perhaps ever seen before. Is that not correct?

MR. VERSLUIS: Yes. I thank you for pointing that out. For example, the base case we're comparing with, of course, has a once through fuel cycle. We have various criteria that have to do with the waste and use of fuel, but particular the waste forms that can be achieved by other fuel cycles.

So, you're very right that we are not just looking at the reactor, but the entire system from soup to nuts, so to speak.

DR. APOSTOLAKIS: If we go to slide 3, you had the word "excellence" under "safety and reliability goals." What exactly does that mean? That you don't want excellence on the other goals or that this is something special here?

MR. VERSLUIS: Actually, it is something special. And I would like almost to defer to Neil who is going to be discussing those tomorrow. But I can say that there is a strong feeling among the GRNS that one of the important issues in improving the technology and also making it safer is practices of excellence in operations, maintenance, design. And as such, they have made a specific goal with that title and it translates into criteria and metrics having to do with safety to the public during normal operations, frequent occurrences all out -- throughout the fuel cycle, not only the reactor but also the other fuel cycle facilities. And so there's a number of metrics that have been defined to implement this goal of excellence.

MR. JOHNSON: Mr. Chairman, if I could add to that response? I believe your question actually ties very well into Dr. Powers' question regarding the current operating fleet of reactors and the experience and lessons learned from that, and how that's going to feed into the process.

The goal of excellence truly is looking at, you know, what are the best practices. You know, what has led to the success in the current fleet of operating reactors and making sure that the new generation reactors, you know, meet or exceed that level of operational and maintainability excellence. So I think that is the intent of those goals.

DR. APOSTOLAKIS: Now when you say reliability goals, I mean are they goals the way we understand them, numerical goals for reliability? For safety I understand it, but reliability?

MR. VERSLUIS: That's where we would like to end up, but reliability you can't really put a metric of reliability together until you know the design pretty well.

DR. APOSTOLAKIS: Sure.

MR. VERSLUIS: And so early on we are really looking at very general indicators that might lead to reliability, but it's not -- as I remember well, it's actually not a screen for potential criteria. It doesn't come into play until later.

DR. APOSTOLAKIS: And a last comment, if I may.

On the third column, "Economics Goals," it says "risk to capital." That's a very interesting idea. I mean, do you envision at some point in the future that we will have a probablistic risk assessment for a proposed design that in addition to end states that involve various levels of damage to the core, we'll also have other end states that refer to economic losses? I mean, that would be a very exciting thing to do, actually.

MR. VERSLUIS: Well, I don't know if we need new methodologies along that probablistic risk assessment line. But, yes, there are now ways of assessing risk for a certain project and what we want to indicate here is that nuclear energy systems when investors look at them, the risk to their capital should be comparable with other projects.

DR. APOSTOLAKIS: Which is intimately tied to the second column, right, "Safety and Reliability Goals"?

MR. VERSLUIS: Yes. Well, actually, many of the other goals, of course, have an economics impact. Definitely, yes.

DR. KRESS: I know you wanted to leave something for Neil Todreas, but under that "Safety and Reliability Goals" you have emergency response. Could I read that as no emergency response?

MR. VERSLUIS: The goal is in fact to eliminate the emergency response. And this may be a good time to reiterate what Bill said. These are goals that drive R&D programs. They are not regulatory criteria. In fact, we take pains to point out that it may not be possible to reach all these goals, but we will be evaluating the concepts on how well they get there on a scale from, you know, zero to the goal; how close they get and across how many goals.

MR. LEITCH: I'm trying to better understand the level of effort that's going on. These 50 U.S. experts and 40 experts internationally, are they involved full-time or only at times of these meetings that you refer to? In other words, between meetings what are they doing? Are they back home working on this full-time or is this just part-time?

MR. VERSLUIS: We didn't mean anyone to be working on it full-time, but they are expected to work on these issues between meetings or the work wouldn't get done.

DR. APOSTOLAKIS: It's pretty much like the ACRS, I guess.

MR. VERSLUIS: Yes, right.

Roughly speaking we expect people to spend some 20 percent of their time on the roadmap and in the chairs, the co-chairs of these groups some more time.

The international participants, again, they're expected to do the same thing but they are funded by their own organizations. Nevertheless, there is a lot of work to be done here, which they all recognize, and there is a real sense of wanting to do this correctly. So, we are probably getting a little more than we are paying for.

MR. LEITCH: And these individuals are sponsored by their parent organization, either industry or academia or labs? In other words, DOE's responsibility is the oversight and management of this program?

MR. VERSLUIS: For the U.S. participants we contracted most of the individuals and our total budget is $4½ million for this year.

MR. LEITCH: Who do you see as the customer of this activity?

MR. VERSLUIS: Well, the customer at this point is DOE, because we are looking for guidance on our R&D program in the long term. And we also are looking for a well-reasoned, a well-organized plan that allows us to discuss our needs with Congress and with other agencies.

But ultimately, and this is one of the reasons we have gotten the utilities -- I'm sorry, the industry, owner operators and vendors involved very early on, because we feel that they're ultimately the customers for these efforts. And as I ended up my talk, I said we need to be able to define a hand off to industry at some point.

At this point I would say DOE is the customer.

MR. LEITCH: Okay. Thank you.

DR. KRESS: With that, I think I'll stop the questions and move on to the next speaker to keep us on time. The next speaker is Mr. Thomas Miller.

MR. MILLER: Thank you. My name is Tom Miller. I am in the Office of Technology and International Cooperation. I'm responsible for the near-term deployment working group of the Gen IV roadmap effort. I'm also the project manager for NERI and the INERI programs.

Very early on in the Gen IV roadmap effort we realized that the effort in the near-term was going to determine a lot of what happens out in the future 2020/2030 time frame. We didn't have a nuclear component, a new nuclear component in the 2010, the 2020 time frame there probably wouldn't be something beyond that. So we looked at what it was going to take to have new nuclear plant deployment in the U.S. by the year 2010. We picked that target date, and as Bill said we're a little bit flexible on that date, but that was our target date with the intention of having new plant orders by 2005.

And the intention was to have not only plant operational, but to see what it would take to have multiple plants in operation by 2010. And by that you can see some differences of how you may approach things if you have multiple plants being built.

The participants, and it's a multiindustry oriented organization because of the near-term effort, we have nuclear utilities; the major utilities that are involved in the nuclear power generation to date and those that are looking to the future in nuclear power are participating.

The reactor vendors, national labs Argonne and INEEL. We have academia through Penn State University participating. Industry is also participating through EPRI. And we have participation of our NERAC committee on our panel.

Early on we identified two deliverables that we felt were important. One was a working group set of recommendations early that we called the near-term actions for new plant deployment. That near-term actions was intended to offer DOE some recommendations based on the experience of the group itself without any outside input, and it was intended to offer up recommendations that could be used by the Energy Policy Committee by the Vice President and DOE and the lobbyists in helping support the department's budgets in FY '02 and '03.

The longer term product of this group was a near-term deployment roadmap that's targeted for September of this year.

In the near-term actions the things that came out of our group were recommendations involving early site permit demonstration, combined construction/operating license demonstration, certification of the 1000+ MWe ALWR and confirmatory testing and code validation of advanced reactors using new technology. In effect, support code validation and testing requirements that industry might not be able to do for the gas reactors.

Supporting this effort we issued a request for information to the general community with targeted directions to specific groups. This RFI was issued in April with a request to have material back in May, with a one month turn around. As it turns out with most RFIs, we're still having some information come in.

The RFI was issued to the public through the CBD. We gave a directed submittal to the members of the NEI New Plant Task Force, directly to the reactor vendors to facilitate getting a response back in this one month time frame.

What we were asking for was to identify the design specific generic institutional regulatory barriers to new plant deployment, identify the gaps associated with those. And in the RFI we broke it down in various sections that looked at reactor specific design issues and site related activities and generic barriers.

We received responses from 12 organizations, and right now those are being reviewed by the panel.

The RFI requested these designs, the reactor designs to meet six specific criteria. And these were intended to assure that they could meet the 2010 time frame, and it was intended to weed out other designs that might have fallen more under the Gen IV category rather than in this near-term deployment.

You all have these in the handout, and I don't intend to read through them, but they were focused on things dealing with: How the reactor vendor planned to gain regulatory acceptance; did he have an infrastructure that would support the deployment of his design; what was his plan for commercialization of the design; if he had a particular utility that was interested in or not; if not, how was he going to get it into the marketplace; if there was work to be done and there was a need for government level support, what is the cost-share, how would they want to implement that and what are the specific activities; they had to demonstrate economic competitiveness to assure that they could compete in the marketplace that was there within the next 10 years. And one of the most interesting was that they had to rely on the existing fuel infrastructure.

Then we also addressed generic gaps. And in the RFI we identified specific gaps that we, as a group, knew already existed and asked the respondees to rank those generic gaps and identify additional ones. And in ranking those generic gaps, we also asked them to identify what they believed were solutions and appropriate levels of funding to reach those solutions.

The responses we got in the design area are on the slide. Typical that we expected from Washington and GE responses. We got responsible on gas reactors from Exelon/PBMR and General Atomics. And one we had not expected, but showed up, was from Framatome, the SW 1000.

At this point of time the group is evaluating these designs. We're conducting a two level review, one based on the six criteria and then we're going to do a summary level design review of each design and look at it from that perspective.

As expected, the generic gap responses that came back pretty much matched what the working group believed as necessary, but there were some additional ones that were identified.

The three first ones involve parts of demonstrating Part 52 licensing requirements. Identification now shows up with the risk-informed regulation for future design certification. And there was a specifics identifying emergency planning and plant security issues.

The last six were identified by organizations that were not the reactor vendors or your typical utility, but were other inputs we received from the national laboratories and other concerned nuclear industry groups, and they provide some input for the group to consider.

Brought up earlier was the idea of economic risk and risk assessment tool, and in fact one of those was identified in our group.

As I want to state right now, we're on a track to issue this report in September. The working group is split off in teams right now. They're diligently looking at these designs. Our next meeting is the end of June, and we'll be having an assessment by each of the design review teams given to the working group, and in addition having the reactor vendors come in and demonstrate to the working group how they meet each one of these criteria.

And at this point in time I will conclude, because there really is no further information I have to give the committee.

Thank you.

DR. KRESS: Thank you.

Questions?

MR. WALLIS: I have a question. A lot of your criteria is the credible plan for gaining regulatory acceptance. Now, presently there's an infrastructure for doing this. Response to things like regulatory guides and standard review plans and so on. In the absence of those from the NRC side, how are you going to have a credible plan for gaining acceptance?

MR. MILLER: This criteria was focused towards those industry groups, utilities or vendors that were going to come in with a new reactor design and they had to show how they were going to try and either meet Part 50, Part 52 and have a design that was either accepted by the NRC or design certified and ready to be built and operational by 2010.

From the experience we've seen with the ALWR program, there is a timely process. We're asking these vendors to come in and tell us how they had planned to get through that process.

DR. POWERS: One of the frustrations, I think, the agency has when it confronts new designs or anything new with the regulations is that the applications tend to come in piecemeal and whatnot. There's some effort here to have more comprehensive, better quality applications coming in?

MR. MILLER: We're not addressing that.

MR. LEITCH: One of the significant activities that you list is design certification of a 1000 megawatt ALWR. Does that suggest a predeposition to large reactors versus smaller modular designs?

MR. MILLER: No, that's not a predeposition. That is one of the responses we got back. We also got feedback from the GT-MHR from General Atomics, which is a small design, the pebble bed reactor design, which is a small design. There was also a response back from Westinghouse for the AP 600. So, I don't see a predisposition to larger plants.

DR. KRESS: If there are no more questions, we'll follow on to the next item on the agenda, which is Mr. Johnson. Mr., Mr. Versluis again.

MR. VERSLUIS: Yes, that's me again. Yes. Thank you.

I'm going to talk a little bit about the Generation IV concepts that we have received. And I'm going to take you on a whirlwind tour and scare you a little, probably, in the regulatory area.

We felt that we needed to take a good look at all concepts that could show promise, particularly since we have built in a good period of R&D, we really want to look at concepts with the proper amount of R&D and can meet the goals or can advance very much through the goals. And we started also with a request for information in March. That request closed sometime last month, a few things have still been dribbling in. It was published in the Commerce Business Daily, the Federal Register and was also distributed very widely in the international community.

We now have about a 100 responses, and I'm going to be talking about the key features and the statistics, and basically you're getting this hot from the press without much digestion because we just got them in. But I'll talk about grouping and then the current activities.

This is the definition we've already gone through, so next.

We received totally 94 concepts, but we

also had internally generated some of the concepts and not all of these here were full energy concepts. So we figure we have about a 100 total, and this shows the breakdown by different coolant technologies, by country and by organization type. And I will leave this for you to pursue through at your convenience and go to the next slide.

And this shows the variety of concepts that were received. Going to the water group, and these were reported by the water group, the variables that they recognized in looking at these concepts are: The coolant, light, heavy water; phase and conditions; thermal, epi-thermal and fast spectrum; primary system layout - there were a number of integral PWR types but also conventional; the fuel cycle - uranium and thorium once-through various recycles; the thermal output and particularly also the maturity of concepts, different.

Some of the crosscutting R&D issues that they immediately identified for all of these are high temperature materials, modular manufacturing technologies, internal control rods and I&C issues. That doesn't mean that these are the only ones, but those jumped out when I first looked at them.

In the gas group the variables they

recognized are the reactor concepts and the applications of fission heart. And within the reactor concepts there were the gas turbine modular gas cooled reactors, PBMRs, fluidized bed reactors and a gas cooled fast reactor.

And there was a great variety of the applications, the energy products for which the fission heat could be used: Electricity generation, both direct and indirect cycle; various process heat applications as well as district heating and desalination.

They recognized different fuel forms and fuel cycles with uranium, thorium and uranium plutonium. There are good plutonium burners, the gas reactors, so there were a number of concepts that focused on that.

And their generic R&D issues are: The fuel fabrication quality assurance; fuel performance -- integrity and fission product retention; lifetime temperature and irradiation behavior of graphite structures; high temperature materials and equipment; and, passive heat decay removal for fast-spectrum concepts. Fast-spectrum concepts have less of a thermal capacity because many of the lighter elements have to be removed.

The liquid metal coolant, the variables are: the size - large/monolithic designs, modular designs, transportable designs - and targeted clients. And I think I'm not sure what they meant through that, but I think it means a transportable reactors that you can take to less developed areas of the world with less stable grids and less of an infrastructure.

Different coolants, sodium, lead and lead alloys.

Fuel type, oxide, metal, nitride, composites meaning the entire spectrum that you can think of.

Primary system layout, look and pool.

BOP options and energy products also there.

Energy conversion options that include some pretty advanced things like Mtech, the thermal electric conversion and other high technology MHD was also in there. And fuel recycle technology, aqueous and dry recycling.

Now in the non-classical concepts we may have to ask assistance from Commissioner Diaz because so many different things came in and he has a lot of experience with some pretty way out designs.

The focus of this group is on adequately defined concepts with significant potential, and the variables there are: The cooling approach; the coolant itself, molten salt, organic; the fuel phase, solid, liquid, gas and vapor; electricity generation technology conversion including a direct fission-fragment energy conversion; alternative energy products or services; and also the fuel cycle.

The crosscut issues that they identified are: Modular deployable; hydrogen production and very high temperature systems; advanced fuels and fuel management techniques; and energy conversion systems, especially non-Rankine.

Now, I'd like to say something about the grouping, because that's really the first step of our work is to look at this entire group and organize them, and get them ready for the first screening.

All the TWGs, all the working groups have taken a first cut at the grouping them into concept sets that share a technology base and a design approach. And rational for the grouping is, first of all, the efficient division of the analysis effort, but also the streamlined evaluation process and an avoidance of premature down-selection at this point when there's so little information available about some of these concepts and we run the risk of throwing out the baby with the bath water.

For the water group we found we have three PWR loop type reactors. These are, in fact, the sets. Three PWR loop reactors, a set of three. Integral primary system PWRs, six. Integral BWRs, six. Pressure tube reactors, three. High conversion cores, 11. Three supercritical water reactors and then 14 advanced fuel cycle concepts of various types, you can read.

The gas group there were five pebble bed modular reactor concepts. Five prismatic modular reactor concepts. One very high temperature reactor operating at ~15003°C. Five fast-spectrum reactor concepts, and four others including fluidized bed and moving ignition zone concepts.

The liquid metal group looked at four major categories and concepts: Medium-to-large oxide-fueled systems of which there were six; eight medium-sized metal-fueled systems; eight medium-sized Pb/Pb-Bi systems; and six small-sized Pb/Pb-Bi systems.

They're also examining three supporting technology areas: oxide, metal and nitride fuels; different coolants; and different fuel cycle approaches.

And in the non-classical group, as you can see, they were not real successful in creating a lot of economy here with the grouping, but there are some.

There are two eutectic metallic fuel types, four molten salt fuel concepts, a gas core reactor, a molten salt coiled/solid fuel reactor, an organic cooled reactor, a solid conduction/heat pipe reactor and two fission product direct conversion systems.

Okay. I hope this didn't scare you too much.

The current activities now with the concepts in the working groups is to analyze these candidate concepts for performance potential relative to the technology goals and to start working and identifying the technology gaps.

And this fiscal year a report will be prepared to describe these concepts and we have laid out a format for that. We want all the concepts to be described in a similar manner. The R&D needs will be covered in that report. And the results of the initial screening for potential evaluations.

And that's where we are.

DR. KRESS: Questions?

DR. SHACK: One of the things I noticed this morning in the whole discussion of the Generation

IV thing was that the word "severe accident" never appeared anywhere. Do you envision that as being a technology need that will have to be addressed in the R&D program?

MR. VERSLUIS: Yes. One of the goals, the second safety and reliability goal has to do with core damage. And then the third goal has to do with the emergency response. So in both of these goals severe accidents are an issue.

And the second goal will assume the performance of a PRA. And the third goal will have to involve all the severe accident that could lead to a release off-site.

Does that answer your question?

DR. SHACK: I guess so. You know, I guess my question is are you going to handle it by essentially your PRA argument that core damage is so unlikely that I don't have to address a severe accident, per se? Or do you really envision a need, for example, to determine source terms for some of these reactor concepts?

MR. VERSLUIS: Well, for those concepts that are selected that make it through the early stages of the screening, there will have to be a better description of source term and the various scenarios leading to the source terms, yes. But early on, as you can see by this wide variety of concepts, we're going to have to use surrogates and indicators with potential and severe accidents.

And we are looking at physics parameters, at heat capacity at the typical things that you would look at to determine whether or not it's likely to -- and what the passive severe accident would be.

DR. FORD: We've been told earlier on that risk-informed regulation is going to be a part of your strategy, and yet we're looking at a whole lot of new systems here for which we have no experience at all in terms of time dependent degradation. So as you're going through your screening process, does the time needed for R&D to resolve those questions, does that enter into your timing, your decision making?

MR. VERSLUIS: Yes, it does. And certainly we hope or we intend but in early on in particular to focus on those issues where there's a large amount of uncertainty and try to reduce that uncertainty. That's how we will focus what we call the viability R&D, so that we have a better idea of what the potential is to really meet --

DR. FORD: And have you also taken into current the question of manpower capable of doing that research?

MR. VERSLUIS: Well, there will of course be as part of the roadmap an estimate of required manpower, resources and infrastructure. But we are certainly aware that there is a lot of work needed there and a lot of investment needs to be made. I should probably let Bill Magwood talk to this issue, because this is wider than just the Generation IV.

You want to say anything about that?

MR. MAGWOOD: Well, I think it's always important to think between time and maybe the distinction wasn't made as cleanly. But when Tom was talking about the near-term deployment, we're aiming for systems, and I think you can tell from the types of technologies Rob was talking about, that on Tom's side will be deployable before 2010. And then the case that Rob was talking about, we're talking about systems that will be deployable by 2030.

So, clearly once we make a selection of the concepts that should be pursued, the roadmap will lay out what the R&D programs should look like. And that actually is a little -- to some degree. You know, rather than simply saying we need to maintain a healthy university system, we need to maintain a healthy infrastructure to make sure that we'll be able to develop advanced concepts, we'll be able to point to the technology roadmap and say we can't do that because the infrastructure doesn't look like the following, we don't have the kinds of professionals available.

One really good example in the United States, and I think some of you are aware of this, is that we're in pretty poor shape when it comes to nuclear chemists. There just aren't very many left and a lot of them are retiring. And the universities aren't putting out any more nuclear chemists. So, you know, as we get into some of these areas, especially molten salt reactors and things like that, you know, you're going to have to know that you have nuclear chemists available to go off and do this research over the next, you know, ten or 20 years.

So clearly the roadmap itself will become a vehicle for us to get a better handle on the kinds of requirements we need. Right now it's very speculative, it's very high level, there aren't a lot of specifics.

For example, NERAC has rolled out a long term R&D plan to cover the wide area, but it doesn't focus on specific concepts. This will do that. So I think that there's time to respond to the need.

But Rob was right, the much bigger issue is support.

MR. WALLIS: When you were listing all these concepts, it reminded me of the '50s and '60s when there was a blooming of dozens of concepts, rather like these ones and only two or three survived. So, there's a sort of a redoing about this and I'm trying to think about what is it that's going to make a difference this time? Are there some breakthroughs in technology or are there some changes in criteria, or something which will make a difference this time around?

MR. VERSLUIS: Well, I think you answered your question partially yourself. There are indeed new materials.

I also think that there has been an new recognition among policymakers and the public that we'd better start some planning for our energy future and issues like sustainability, climate issues they now play a much bigger role than they did 40 years ago when we designed the first round of technologies.

But, yes, in fact when you look at the technologies that have been submitted, many of them are really not new. But it is time to look at them with the eyes of today, or actually the eyes of mid-century and the need for hydrogen production and the need for clean water, and the need for other energy products.

And in addition to that, of course, there is the change in the market structure. There is deregulation of the energy markets. There is the internationalization of the vendors as well as the owner operators.

So, really the environment for judging these technologies has truly changed and it is worth looking at them again.

DR. BONACA: Yes, going back to the question of severe accidents, we call today severe accidents those accidents which were not considered as part of the original design basis of the plans. Are you going to have designs that address all kind of severe accidents, or something akin to what we had in the past?

MR. VERSLUIS: There really is no doubt among the roadmappers that the concepts that are selected for the development as we get further into the development and designs are becoming more specified, that they have to be shown to be safe. I mean, there's no way around that. And I'm not sure how to answer your question other than, we're not looking for cutting corners on safety. In fact, we are hoping to make advances towards safety.

DR. BONACA: So essentially the design basis of the plan will include consideration of severe accidents?

MR. VERSLUIS: Yes.

DR. BONACA: What we call today severe accidents?

DR. GARRICK: Rob, one of the things that bothers me a little bit about this program is that if I look at other programs like the Apollo program, the atomic bomb program, et cetera, et cetera and ask what was the real driver, where was the real cadre of activity and creativity, and they of course had very specific groups that constituted the think tank and the nucleus of where everything kind of emanated from, and I'm also thinking of the model that I think is a very good one, the Lockheed Skunkworks. Here was a small number of people that just generated immense breakthroughs in terms of solving these kinds of problems. I don't see that here.

I see a lot of review groups and I see a lot of proposals from different organizations, but I don't see -- and I don't know what this has to do with regulatory challenge, but it might because they should be part of that team, too. But I don't see the kind of inspiration and drive that comes from a Von Brun group that is putting together the rockets that are going to get us to the moon. And yet the time constant here is much longer than any of those programs.

How is this all gelled together in terms of a first rate group of people that we really look to make it happen? Maybe Bill has to answer that one, I don't know.

MR. VERSLUIS: Well, let me take a first crack at it. I mean, I'm not sure I understand --

DR. GARRICK: I'm looking for the core group.

MR. VERSLUIS: Right. What I wanted to do at least is to point out that we're not only working with the U.S. expertise, one of the things that Bill has insisted in, and he's very right about that, is to expand this into the world, and particularly into the nuclear community with credible programs. The people like the Japanese and the French that bring a lot of resources and expertise to the table that we are just kind of hanging on to.

So, I think that looking at taking a wider view, there is a lot of resource or a lot of capability available.

You were saying how can you focus it to --

DR. GARRICK: Right. Right. Where is the Robert Oppenheimer group? Where's the Skunkworks group? Where's the group that really is the driver?

MR. VERSLUIS: Well, they need money, and this is -- and Bill can correct me if I'm not representing this correctly, but this is a way to in a fairly transparent manner make a strategic plan where you start with all the concepts that you can find and you narrow down to the most promising ones, and then you focus your R&D on those.

So, perhaps the answer to your question is we will get a focused effort, we will get a -- I don't know if it's a small group, we hope it is, with enough resources there to do the R&D that needs to be done. But it will be focused and it will be done on a small number of promising concepts.

MR. JOHNSON: John, if I could take a shoot at answering your question. With all respect, I'm not sure the analogy is an appropriate one because those former federal programs were really single objective oriented in terms of creating the bomb, putting a man on the moon. What we're talking about here is developing the enabling technologies and getting those technologies to a point for a hand-off to industry and industry to make a decision on whether to take those technologies and commercialize them and apply them. We're not advocating the United States get into -- the federal government embark on a reactor design deployment mission here.

DR. GARRICK: Yes, and I'm not even saying it has to be the federal government. Because, you know, the Skunkworks model was not necessarily a government program. But, yes, go ahead.

MR. JOHNSON: Oh, I was finished, John.

DR. GARRICK: Okay.

DR. KRESS: Seeing no other questions, let's move on to --

DR. APOSTOLAKIS: Just a minor comment.

DR. KRESS: Oh, okay. Comments, questions.

DR. APOSTOLAKIS: I wonder whether for the new concepts we should also rethink the terminology that we've been using, which is of course water reactor driven. There was a discussion on severe accidents a few minutes ago, and I don't know that we really want to carry over this terminology and other similar stuff.

So, I know this is a detail at this point, I mean you're thinking about much bigger things. But it seems to me that's something to have in the back of our minds, whether we want to continue using some of the terminology of the past, especially since one of the earlier goals that were stated was public acceptance.

MR. VERSLUIS: I think it's something that we should think about. We really haven't delved into severe accidents much at this point, and it may well be a good time to review the terms. Thank you.

DR. KRESS: Yes. That's a concept that comes about because we have been used to design basis accidents. And in order to separate the two, we'd call them severe accidents. And it almost seems like an arbitrary separation.

I don't know. My question is are you going to try to fit -- well, I guess it may be premature to ask this, but fit the licensing of this into a design basis concept to fit it into the current regulations or are you going to try to develop PRAs that are sufficiently acceptable that you couldn't go completely a risk-informed route? I guess that's my question: Are we going to stick the design basis concept?

DR. BONACA: The reason why I think is

important, however, is that we're still having to deal with credibility of an accident. What is the most limited credible accident. I mean when the current design basis was defined, is because it was believed that that was the most credible accident, the most limiting ones. And so in good faith people put limit to the -- and that yet is going to be challenging in the course of --

DR. KRESS: There's a whole issue of how do you go about defining design basis accidents.

DR. BONACA: Exactly.

DR. APOSTOLAKIS: Yes, it's very interesting because the first paper on risk in 1967 by Reg Farmer raised the same question; is it logical to consider to have a distinction between credible and incredible accidents.

DR. POWERS: And I think we have found the limitations on the maximum credible accident kind of concept. I was fairly excited when one of the speakers said that the approach was that once they had refined down their list of viable concepts down to a more trackable few, that they would then look more carefully at the source driven. It seems to me that's where you'd look rather than the accident scenarios. And I think this is a place where we need to come back and revisit what we discussed in the past on frequency consequence curves, which is actually coming back to your man Farmer a long time ago that this may be a much more valuable direction for us to take than the classic level one, two, three kinds of approaches and design basis accidents versus beyond design basis accidents.

I mean, it's a much better continuum to look at rather than these categorizations.

DR. APOSTOLAKIS: So you were excited earlier, Dana, and now I'm excited.

DR. POWERS: Well, we actually find some use for those probablistic things that you do, but we'll get into some really good metallurgy stuff here in a little bit.

DR. KRESS: With that, I'd like to move on to the next speaker, please. Mr. Johnson, you're next.

MR. JOHNSON: Yes. Thank you.

Good morning. My name is Shane Johnson, and I'm the Associate Director for Technology and International Cooperation for the Office of Nuclear Energy at the Department of Energy. And what I'm going to do briefly is just try to summarize what you have heard over the last hour and 45 minutes from our discussion this morning. And that is, where do we go from here?

You've heard us talking about our Generation IV activities, our Generation IV activities being defined as both the near-term deployment activities as well as our technology roadmap development.

Before I embark on summarizing that, I would just like to say to get back to a question that the Chairman put early on relative to the regulatory challenges. And that is we have recognized that in both our near-term and our longer term activities that there is an inherent regulatory facet to the programs.

For example, these two activities, both our near-term deployment as well as our longer term Generation IV technology roadmap, while we have got them linked to under a single program, they are somewhat as you've heard significantly different in terms of their objectives and the time frames.

Our near-term deployment group really is focused on identifying regulatory and institutional barriers that exist in the United States for deployment of new nuclear assets. And we have also approached that in looking in terms of technologies that require no or little further development. So our near-term deployment activities are really focused at the regulatory environment in the United States and has very little in terms of a focus on technology development.

Our Generation IV technology roadmap is really just the opposite end of the spectrum of that, and that is we're looking at in terms of the Generation IV technologies is truly technology development. Looking at technologies that are, hopefully, stretching our current knowledge of reactor design and operation. But simultaneous with that, while we don't want to lose sight of regulatory implications, again it's a technology development program and the regulatory aspects of deploying that technology are going to come, again, in the future.

The Department, as the Committee well knows, is the federal government's technology agency as opposed to the NRC, which is its regulatory body.

But in our activities we have been working, in both the near-term activities and our longer term Gen IV activities, with the agency. We have been working with the Office of Research here, Ashok Thadani and his staff, in both the near-term deployment activities as well as our Generation IV technology activities and having a representative from the Office of Research involved especially with our Generation IV International Forum. John Flack, one of Ashok's staff here, has had the privilege of trotting around the globe with us as we engage the international community in the Generation IV technology arena.

Quickly to summarize, first I'd just like to address those things on the near-term deployment activities, as Tom Miller went over earlier. And that is our goal in our near-term activities is to complete our near-term deployment report by September of this year. The report will identify primarily generic issues that the government could pursue in a cost share cooperative basis with industry to establish an environment that will enable industry to step out and make informed decisions on the deployment of new nuclear assets in the United States. Those issues as it appears right now primarily are going to be related to early site permitting, going through that untested process, as well as the combined construction and operating license process.

We are also working with the NRC in helping them to get started in the development of generic advance gas reactor regulatory framework, because as everyone knows it's an area that needs some work and there are organizations in the industry who are coming forward and having those discussions with NRC, so it is a responsibility of the federal government to be prepared to address these technology concerns. And we're glad to be working cooperatively with the NRC in aiding them as they develop these generic reactor technology regulatory framework.

With respect to our Generation IV technology roadmap really our near-term actions, as Robert Versluis has summarized, is to take the almost 100 concepts and to go through a systematic evaluation of those concepts and identify those concepts which are most promising which to the extent at which we are able to make such an evaluation at this time, meet the technology goals that have been established by our nuclear energy research advisory committee as well as our Generation IV International Forum. And after identifying those most promising concepts, is to put together the comprehensive research and development plan that will, hopefully, lead to the development of these technologies and bring them to a point at which time in the future they can be handed off to industry for further and eventual commercialization.

And with that, I believe our discussion on the Generation IV activities is complete.

Mr. Chairman.

DR. KRESS: Questions for the speaker or any of the previous speakers? I guess we must be hungry. Ah, there's one. Please identify yourself.

MR. LYMAN: Ed Lyman again, Nuclear Control Institute.

I just have to follow up from my earlier question, because I think what we've just heard is a list of activities which I don't think it's appropriate for the government to be funding. These are activities which are associated with providing a regulatory climate or easing licensing advanced reactors. And I think in today's context, that's a cost that really should be born by the applicants.

Licensing is expensive, but that is part of the package for trying to develop a new nuclear reactor and market it. And so I think it raises real questions whether DOE should be involved in trying to facilitate or come up with ways of easing the site permits and other regulatory activities.

I'm also concerned about DOE proposing a licensing framework for reactors and then a way of meeting those licensing criteria. I think there really has to be a separation maintained between the licensing standards and the actual applicant. Because otherwise these criteria could be gerry-rigged to justify or to facilitate the particular reactor you're pushing.

MR. MAGWOOD: Again, Ed raises an important point and I think it requires a little bit of distinction drawn.

What we're doing, Ed, and for everyone else who had concern about this, is we're focusing on generic issues, and this is something that DOE has done basically throughout history.

For example, in the case of gas reactors there are some very generic issues related to the implementation of gas reactor technology in the United States whether it's a pebble bed or GT-MHR or something else, you have to deal with, for example -- and this is something that we've had a lot of very important discussions about. If in the case of a case reactor you're relying very heavily on the quality of the fuel, how does one go about thinking about fuel manufacturing in concert with the design of a power plant? You can't separate it as easily as you can in the light water reactor. That's a very, very broad generic technology issue. And I think it's entirely appropriate for DOE to be involved in that.

What we will not be involved in are the

specific -- and NRC, by the way I'll point this out, NRC's Office of General Counsel has been very, very diligent about keeping both NRC and DOE straight about this issue.

We will not contribute to the specific design related regulatory activities NRC will be participating in with the vendors. There will be a separate activity that will probably be coming on in the next year or so. We expect that Exelon, or whoever, will come to the NRC and will be obligated to pay for those activities. We don't anticipate being involved in that.

But the generic activities are things that we think the government ought to be involved in and should be involved in. And I'll be happy to talk with you more about that later, but I think it's entirely appropriate what we're doing as long as you stay on this generic level. I think there has to be a distinction.

DR. UHRIG: There's a number of rather exotic materials involved in the various concepts that have been talked about this morning. Is there any consideration or any time being spent looking at the availability of these? Even something as common as hydrogen -- I mean helium, excuse me, there's a limited amount of that unless you want to produce it artificially. And I just wondered if this is an issue that's going to be brought into the consideration?

MR. MAGWOOD: That's a really good question, and something that I've actually started to worry about myself. The answer to the question is no, we haven't done this stage. And the reason we haven't is because we haven't reached this 2002 target of narrowing down the number of options. When we know what concepts we're really going to spend our energies on, we're going to really have to deal with those materials issues.

And I can't talk too much about this, but we are expecting in the next few weeks to really strengthen our materials activities within the DOE infrastructure and start to have more focus on these issues. Because I think they're too disperse right now. We need to really focus our energies there, and we're going to be doing that very soon. We'll make some announcements about that.

But your question is really good one, and we're worried about it but it's too early for us to really go a whole lot further.

MR. UHRIG: I guess my point was that this could e an issue that would eliminate an otherwise attractive concept.

MR. MAGWOOD: Well, that's a really good point. I mean, for example if we don't have enough helium for the helium cooled reactors --

MR. UHRIG: I think that's not a major issue, but it's something that certainly should be looked at.

MR. MAGWOOD: Yes. I think it's something that will have to be looked at in concert with the evaluations that NERAC is doing. I mean, I'm not aware of any major materials limitations. If someone has some exotic material that, you know, it's just not available, I expect that will become one of the technology issues. And if it is such an issue that you simply can't rely on being able to build numbers of plants, I would expect it would be kicked out on that basis. So, I think that's something we ought to take back to the group and make sure they're conscious of that. So, I appreciate that thought.

But so far I've never heard of any exotic material that would simply eliminate a concept being considered.

MR. UHRIG: Thank you.

MR. FEINROTH: My name is Herbert Feinroth.

As I listened to some questions from the ACRS and also the DOE presentation I sort of see a different -- there's a gap between what the DOE is focusing on, which is the entire fuel cycle not just the reactor and their interest is in these goals that they've described to achieve safety and public health for the entire fuel cycle. Whereas the ACRS is focused, I believe, in the past and I think still on reactors only. And it seems to me that this is more of an observation than a question, because I don't the question has an answer that the regulators need to look at the whole fuel cycle as well and not just the reactor as they provide advice or input to the DOE in their section process.

The gentleman asked about the source term. Well, the source term of importance to public health is not just what's in the reactor, but what gets transported, but gets recycled, what gets sent to a repository. So I think the context that DOE is looking at this is correct. And I think the regulatory agency needs to figure out how to address the imbalance, the public health from the different parts of the fuel cycle. And my concern is the ACRS just looks at the reactor.

I don't know if anybody has a response to that, but I think that's an issue that needs to be addressed by the regulatory agency.

DR. POWERS: Well, we'll comment quickly that we do have the Chairman of the Advisory Committee on Nuclear Waste look at the waste portion of it. And that ACRS does also look at the fuel fabrication part of the problem as well, though we probably haven't focused on it very much in the discussion today because the fuel cycle has only been mentioned briefly here as being changed.

DR. KRESS: I think the questioner had a good point. I did want to point out that the ACNW also focuses on regulations related to sensitive materials and materials applications.

Perhaps ACRS could do a little more on the fuel cycle parts, but our conception, at least our feeling is, the real risk part of the thing is in the reactor or perhaps in the fuel fabrication.

George, did you want to say anything?

DR. APOSTOLAKIS: And we also have joint committees with the ACNW when the issues warrant it. But it's certainly a good thought.

MR. CLEMENTS: Yes, I'm Tom Clements with the Nuclear Control Institute.

I was a little confused during the DOE

presentation about the relationship between the roadmap and the review you're doing and what's happening with the Exelon pebble bed reactor. From what I hear, depending on what happens in South Africa, they plan to start construction in 2004 and have a reactor operating in this country 2006. It sounds to me like you're behind the curve on what's happening with that reactor. Are you going to ask them to slow down their decision process in pursuing this with NRC? You're behind the curve on what they're doing here on the ground with the NRC or do you assume that you're going to include this reactor in your roadmap? I'm just confused about the relationship between what you're doing and the pebble bed.

MR. MAGWOOD: The pebble bed, that's a good question because I saw something and I thought someone would ask that question.

The pebble bed reactor that Rob spoke to, he spoke to a class of PBMRs, those are not necessarily , in fact may not really all be the reactor that Exelon is interested in and is now being discussed in South Africa. That specific design is being discussed as part of the near-term deployment activities. And, as I've mentioned, those activities are largely complete and will be final -- scheduled to be final through the NERAC process in September, and include largely institutional issues that are being raised by NERAC that are fully in concert with the schedule that PBMR corporation is on.

And, in fact, there are representatives of Exelon on some of the working groups that are providing information about the schedule and trying to keep everything in concert.

So that PBMR is slated for near-term deployment as opposed to being in the longer term Generation IV activities. And that's simply because of the fact that it's of near-term interest to a utility and, therefore, it's appropriate that we look at it as something to be deployed by 2010. And whether it actually gets deployed by 2010 or not is up to Exelon and others.

MR. QUINN: It's Ted Quinn.

Bill or Shane, we've read the Vice President's report -- or the President's report and it addresses investment in new technologies for renewables, for coal for example, and some of the 105 recommendations address advance nuclear. Can you advise in FY '02 and beyond how those recommendations will come into DOE planning?

MR. MAGWOOD: No. To expand on no, nein. Let me just say that, obviously, certainly and our international partners are all very pleased with the outcomes that were in the Vice President's review and have every hope that eventually there'll be more resources devoted to nuclear research and development by the government. Certainly there would have to be to do any of the things that we've talked about today.

What will happen in specific fiscal years, 2002 in particular, I simply don't have an answer for you. I think that as the government continues digest results of the review, we'll begin to talk more in terms of what do we have to do to actually implement those things, and those discussions have already started moving.

But I wouldn't expect to hear any specific implementation announcements other than what you may have already heard from the Secretary. I think he made some announcements recently about specific things in non-nuclear aspects. But on the nuclear aspects it's going to take a while to adjust it, move on it and to formulate those implementation activities.

So I would expect that over the course of the next few months those would start to come out.

DR. KRESS: With that, I'd like to thank

all of our speakers this morning for getting us off to an excellent start. And remind everyone that we have some good things this afternoon on specific designs and some of the regulatory activities that are underway to get ready for this, and some very interesting panel discussions on regulatory challenges.

With that, I'll recess for lunch and ask people to be back at 1:00 please.

(Whereupon, at 12:07 p.m. the Subcommittee was recessed, to reconvene at 1:00 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:01 p.m.)

DR. KRESS: Let's get started again, please, for the afternoon part of this Subcommittee on Advanced Reactors.

Earlier when I mentioned into the record the ACRS members present, I was remiss in not pointing out that Dr. Peter Ford is also here as an ACRS member. So I apologize and get that read into the record.

We are the point now where we're going to talk about Gen IV design concepts, and we're starting out with representatives from Exelon. As I mentioned earlier, I don't have introductory material for people, so you have to introduce yourself. And so I'll just turn it over to you.

MR. LEITCH: Dr. Kress, I'd like to declare that I have an organizational conflict, so I'll recuse myself from the discussions of the pebble bed.

DR. KRESS: Yes. Yes. We need to do that because this is a Subcommittee meeting. Thank you very much.

MR. SPROAT: Mr. Chairman and fellow members of the ACRS, thank you for your invitation today for Exelon and PBMR to come to give you a briefing on the pebble bed modular reactor project currently underway in South Africa.

My name is Ward Sproat. I'm the Vice President of Exelon Generation in charge of international projects, and I represent Exelon's interests on the board of directors of PBMR, the joint venture in South Africa.

Today's presentation is going to cover three areas. One is I'm going to give you a brief introduction and project update about where the project stands.

Second, I'm going to introduce by co-presenter, Dr. Johan Slabber from PBMR Pty in South Africa, who arrived yesterday afternoon with several of his colleagues, and he'll be talking about the design philosophy of the PBMR.

And then finally, I'm going to come back on and talk about the licensing issues that we see trying to license the PBMR here in the U.S.

Well, I'll keep talking and we'll move forward.

Let me just start off with giving you a project overview about where the PBMR project stands. There's been a lot in the press, obviously, about the project some of which is correct, some of which is not correct. And I want to make sure that the ACRS has a full understanding of where the project and where the Exelon stands regarding this technology.

The project is completing the preliminary design stages in South Africa at this point in time. And we are currently finalizing what is called the detailed feasibility report. That report is being generated by the project team in South Africa as well as several contractors, as well as with us, the members of the joint venture. And that feasibility report will be completed sometime probably this summer, at which time then all of the investors in the joint venture will make their own individual decisions regarding whether or not to proceed to the next phase of the project.

The next phase of the project is to move forward with the detail design and the construction of a demonstration PBMR in Republic of South Africa near Capetown on the site of the Kuberg Nuclear Station.

The other investors in the project at this stage of the game, besides ourselves, are BNFL, British Nuclear Fuels Limited, SCOM, which is the electric utility in South Africa and the Industrial Development Corporation of South Africa.

So each of those investors will, in turn, make their own decisions about whether or not to proceed with the project, as well as the South African government needs to make their decision regarding whether or not they'll approve the instruction and operation of the plant in South Africa.

Assuming all of those decisions are favorable, which is not an assured outcome by any stretch of the imagination at this stage of the game, but assuming they are favorable, then construction would start on that demonstration PBMR in South Africa probably in late 2002 and would then take approximately 36 months to complete construction with then a one year start up test program in South Africa.

That's the program in South Africa. As far as Exelon's decision making process and Exelon's involvement, clearly we are pointing to make a decision as to whether or not to continue to proceed as a member of the joint venture in South Africa by the end of this year. We'll make that decision primarily based on economics; do we think that Exelon can make money operating these reactors in a deregulated electric utility market in the U.S. And if so, then obviously we would have to require board of director approval to proceed that way, but it would be our intent to try and make a decision on whether or not to proceed with the joint venture in South Africa by the end of the year.

We probably also make a decision sometime in that time frame, whether or not it's the end of the year or early next year, to begin the licensing process in this country for the first set of PBMRs here in the U.S. And I'll talk a little bit later when I come back on about what some of the obstacles and challenges would be if we decide to move forward with that. But that decision, I think, would also be made sometime around the end of the year, nearly next year as to whether or not to begin the actual licensing process for the PBMR.

So, with that that's the current state of both the project in South Africa and Exelon's involvement in the project.

With that, I'd like to introduce Dr. Johan Slabber, who arrived yesterday from the Republic of South Africa along with several of his colleagues. Hopefully, we have the right people here to answer some of your questions as we go through this. And I'll let Dr. Slabber introduce himself and explain his background.

DR. SLABBER: Thanks, Ward.

Mr. Chairman, ladies and gentlemen. This is a very nice privilege for me to be able to speak to you. And I would like to give you some preliminary information, and then go deeper into the design and the important things regarding the safety as well licenseability status.

Something about myself. My name is S-L-A, although it is pronounced in South Africa as Slabber. In America, if you pronounce it it sounds like Slobber, and that I don't mind. You can say Slabber or Slobber or Slabber.

Something about my background. I was graduated as an electrical engineer with a physics degree. And I did my Ph.D in mechanical engineering, but between those two times, graduations, I spent some nice years in Oak Ridge and I was fortunate to be able to have attended the last -- in the U.S. So I am really indebted to the U.S. for really wetting my appetite for nuclear technology.

I also spent a short time, brief time, at IAEA in safeguards. So in the matter of nuclear nonproliferation, I am also in a position to highlight to you the attributes regarding that aspect of our plan.

The design actually started evolving when

I was an employee. I was General Manager Reactor Technology at the South African Atomic Energy Corporation. But at that stage the Board of Directors said the climate is wrong, the money isn't there, so please let's not look at something although it might be very promising. So that was the point when I departed the Atomic Energy Corporation to a systems engineering company who still today is involved in the project.

This, what I'm going to present to you, was actually developed from the initial concept of a direct cycle turbine generating electricity.

What we have as the philosophy and we, right from the outset, have set as goals inherent safety features employing passive means. It must be modular in size because in South Africa we've got a relatively small grid, but we want high efficiency. And the possibility to eventually supply fresh water for South Africa, it's a semi-desert country. So in 25 years we might run out of water, so that was the focus for the first initial design.

And you will see on the screen there the three bullets which are actually some of the cornerstones of our initial ideas.

Employ passive and active engineered

features, but I would like to qualify this. Because active might sound funny in this context. Active there should be seen in the context of keeping the facility, the reactor, operating within the normal boundaries. In other words, supply cooling, supply ventilation, et cetera. But the passive is to keep it within the limitations which does not lead to radiation release.

The second bullet is rather saying what it is, just that you can mitigate but that you do not have cliff edge effects like suddenly you've got time built into your system.

And then the third bullet actually supports that, reduce dependence on operator actions.

Can I have the next slide? This is, unfortunately, you must see this drawing as it stands at the moment drawn on unigraphics and modeled. But just to show you the width is 25 meters. The length is 50 and the height is 50 and 25 is below grade. But what I would like you to concentrate at this stage on, and it will become clear when we evolve from this, that we have the reactive vessel sitting in an area -- and it's not very clear here -- which is we call the reactive cavity. And we've got the power conversion sitting in a volume called the PCU area and this total strengthened section around the reactor and the PCU we call the citadel which, in fact, is containing, acting as a containment around all those high pressure radioactive components. But I'll come back to that later.

Can I have the next slide, please? This is the complete stuff taken away. What we have here is the reactor vessel of 20 meters high and 6.8 meters diameter. And we have the PCU, and I think I must just explain slightly the workings.

This was the initial concept of changing from a single-shaft turbo generator to a multi-shaft turbo generator employing a high-pressure turbine, turbo compressor, a low-pressure turbo compressor, a turbo generator.

And in the reactor cavity, which we have the reactor cavity cooling system and then below grade we have the spent fuel tanks which can house -- contain the fuel for 40 years of operation, 35 effective years of operations.

It is also designed to store the fuel for another 40 years during the formal decommissioning phase.

The fresh fuel is in the fresh fuel building, and that area we've got the so-called helium inventory control system which employs -- which uses the helium to increase the thermal hydraulic power taken up by the gas in the reactor. And due to coupling of the heat processor co-efficient and the negative temperature co-efficient, the neutronics is just about following the request for semi-hydraulic power.

And then we've got the fuel handling system, which is loading spherical fuel into an angular core in the reactor and graphite spheres into the central and a central reflector. So the core itself consists of an angular pebble bed core with a central column of graphite spheres. And this was necessitated because no control rods -- the design objective was not to have control rods in the core itself, but to have a system where the reactor physics of the core pushes out the flux towards the reflector region for reactivity coupling.

So we've got the fuel handling system, we've got fueling tubes as well as graphite tubes. And we've got -- and we've got some separation of fuel and graphite at the bottom. So this is the PCU. This is the spent fuel, the fresh fuel and the helium control system and the reactor cavity cooling system.

Just at this point we are also taking note of the proliferation resistant aspects that needs to be built in a facility like this. So the reactor safety design principles is actually highlighted in these three bullets.

An objective of the design, to start off with, was to focus the design around existing proven German spherical fuel fabrication and testing technology. That was a go, that was a given. No deviation from that.

And then in the design apart from the microsphere providing the primary barrier, multiple fission product barriers to the environment, to the public outside. And this is not really a safety issue, but we put it under these, and I highlighted it in the previous slide.

Can everybody hear me? Okay.

The fuel itself is a 6 centimeter diameter graphite sphere with containing in the fueled region, which is 50 millimeter diameter, 15,000 microspheres of -- it's got a core of UO_2, it's got a porous region around the microsphere which acts as a fission product buffer, something like the buffer region in a LWR. Then we've got three layers, pyrolytic carbon, high density pyrolytic. The silicon carbide and then other layer of pyrolytic carbon. And the diameter is just under one millimeter.

So 15,000 of these in there and in there the enrichment is 8.1 percent for the equilibrium core and 4.9 percent for the burning core. And the amount of material in that little ball is 9 grams heavy metal.

And around the 50 millimeter diameter sphere we've got a five millimeter unfueled section to take care of abrasion and while this is moving through the core so that you don't expose and allow microspheres to come out.

The first bullet, next slide, to assure fuel integrity. So, as I said the baseline as far as proven technology German fuel and we have been given the opportunity to access and purchase into the total German database which they have developed for their high temperature reactors. And it's been in the process -- for South Africa. And we are actually planning, and I'll come back to that a little bit later, to replicate critical experiments and qualification experiments and tests that were done in the German program.

The next sub-bullet is because it's an onload refueling system, you've got to good control over excess reactivity added to the reactor core under various conditions, and also to ensure under all conditions normal operation as well as upset events you assure removal, heat removal from the fuel by means of passive means.

And prevention of chemical attack, which is one of the events defined as one of the licensing based events, and prevent excess of burnoff.

Now, in the development project we had to structure the project very definite according to certain rules. And for that we have developed the so-called integrated design process in South Africa. It's a PBMR integrated design process which embodies, and we call it the PIDP, the upfront evaluation of any structure system or component, SSC, in its role to mitigate or to cause events leading to the release of radioactivity. And those components are then evaluated and classified according to a scheme which is in line with our national nuclear regulator, the NMR, prescriptions of failure frequencies versus consequences.

And we have the three regimes that we are using in the development of this facility. Events having a frequency higher than 10 to the minus 2, in other words one in a 100 years, we call the anticipated operational occurrences.

And the events lying between -- into the minus 2 and into the minus 6 is the licensing base events. And then the occurrences with a lower frequency than ten to the minus 6, those are the extreme events or the unlikely event.

So what do we do to design a facility in these regimes? The two, the first ones, the ten minus two and -- plus ten minus 2 and between 10 minus 2 and 10 minus 6 we design for all those events. Below 10 minus 6 we analyze for and see what the consequence are.

DR. APOSTOLAKIS: I have a question. I don't understand what you mean by event. Do you mean a sequence or do you mean what we call initiating events?

DR. SLABBER: Yes. Yes. I was explaining the integrated design process, so I interrupted myself just to say what we're focusing at. But it is a sequence. It is initiating event that can lead to a sequence, that can lead to a --

DR. APOSTOLAKIS: So the 10 to the minus 2 refers to this initiator or the whole sequence?

DR. SLABBER: It's the initiator.

DR. APOSTOLAKIS: Now, given that the concept of an event is not really well defined --

DR. SLABBER: Yes.

DR. APOSTOLAKIS: -- I can imagine an event that has a frequency of 10 to the minus 4, therefore I have to design for it, as you said, but then I can break it up into a 100 little pieces each one having a frequency of 10 to the minus 6, so now I don't have to design for it. So, how do you avoid this kind of -- I'm sure you don't it that way.

DR. SLABBER: Oh, no, we don't do it. But we're looking at the logic also. In other words, there are some enveloping frequencies which is also the initiator plus the consequence, the total chain in looking at all the events in between.

I wouldn't be able to completely reply to your question because it's in the process of being done at the moment, but a similar philosophy.

DR. APOSTOLAKIS: But it seems to me when you have to go with the cumulative frequency at some point?

DR. SLABBER: Yes.

DR. APOSTOLAKIS: Because just where you consider in sequences, you know, this is not a well defined concept.

DR. SLABBER: But in any case, thank you for that comment.

DR. KRESS: As you will notice, we've departed from our usual procedure and we'll allow questions that interrupt the speakers. It's just the ACRS can't seem to avoid -- control himself.

DR. APOSTOLAKIS: It was pain from this morning.

DR. SLABBER: In any case, after we have now identified these events, we can for that specific SSC identify a preliminary classification. And then for that specific SSC, we also classify the various loads that it will achieve during its operational and upset lifetime, and we develop a loading catalog. And using the classification which drives the quality assurance requirements as well as the loading catalog and the codes and standards to which the SSC will have to be developed and designed, we call that suite of documents; the design rules for that specific SSC.

The QA requirements, the loading catalog, the classification and the codes and standards, and maybe some other additional things which must -- could come into play like safeguard issues, et cetera. And those are the suite of documents which are the design rules. And then from there, there might be some situations to improve the SSC design, so we can go back to square one. Typically if the failure frequency is too high.

So in the total development of the reactor we have given priority to looking at the fuel first of all. Next slide.

So we look at the fuel quality here and the fuel design which we have chosen has been proven internationally. And another feature that we also embody in the design is that we do not want to develop new material. We will be sticking at qualified materials for all the structure systems and components. This is one component which we have decided we will, as far as practically possible and I agree there will be a question that how do you prove equivalence on such an important issue. This will be done by laboratory tests, PBMR specific tests and irradiation tests, as well as maybe taking part in an international irradiation program.

And this is actually what is said here in this sub-bullet. The fuel qualification program will follow and the fuel performance testing program and the fuel fabrication quality assurance program which is still at the moment already starting to be based.

DR. KRESS: The performance testing program.

DR. SLABBER: Yes?

DR. KRESS: Excuse me for interrupting. Is that under irradiation conditions?

DR. SLABBER: Yes. Yes.

DR. KRESS: So you do this in a reactor?

DR. SLABBER: In a reactor. We will do it stepwise and it will be going beyond the design basis burnup of 80 megawatts, which is presently the design target. But it will be irradiated beyond that.

DR. KRESS: Did you say there were 15,000 of these pellets in the --

DR. SLABBER: 15,000 microspheres in one-sixth centimeter fuel sphere.

DR. KRESS: And how many of those centimeter --

DR. SLABBER: Pardon?

DR. KRESS: How many of those 6 centimeter spheres are in the core?

DR. SLABBER: 330,000. So there's a total of 4.8 to the nine small pressure boundaries, primary pressure boundaries in the core.

Then in the facility, in the reactor there will be an operational fuel integrity assurance surveillance program which will monitor operational release in the primary coolant and to compare it with predicted value.

Next slide, please. One of the other bullets which we've seen is the first one was fuel quality and control of excess reactivity. The reactor is designed to be load following, and to be able to do load following we will use the inventory, called helium inventory control system to pressurize the helium in the primary circuit so that your heat pickup in the core and the heat deposition in the bell conversion unit is in-phase.

Now, to enable you to load follow one needs to also to some extent -- Xenon buildup fission products developed or Xenon developed during the operational cycle. If you reduce your neutronic power, the poison increase. So you've got to cater for during load following operations for a certain amount of reactivity that could be added by means of the control rods. And we have limited that amount to 1.3 delta k effective. In other words, 1.3 niles and this was chosen so that in the event of a stepping out of a control rod without anything checking it, you can add in a random fashion 1.3 delta k to the reactivity. And this is a value of power that will limit you inherently to a temperature, a maximum fuel temperature below the maximum defined limit. I'll come back to that.

We have also provided a measure to design the system so that for all credible pressurization events and reactivity events, if there are anything which will raise the power suddenly, like a control rod injection, the core geometry is always maintained, even in a depressurization event where you could have for a short time a pressure differential across the core barrel.

The core is also, although it's tall it's quite a long core. 8.5 meters high and 3.7 meters diameter with a central column. Although it's tall, it's still within the window which precludes Xenon oscillations. In other words, a critical area at the top uncontrolled and a subcritical area and swinging of the flux. So the geometry precludes Xenon oscillations.

And then due to the nature of the reactor physics of the core, we've got a very high negative temperature coefficient of reactivity. It's minus 4.5 times 10 to the minus 5, delta k over 33 centimeters.

And then we are designing an inherently safe critically safe spent and used fuel tank.

Next slide. The material properties in the core at end of life, and this is now talking about thermal volatility and emissivity is all assumed to be at the risk point and in a static condition with no forced cooling. These material properties are sufficient that the heat can be taken away from the core into the outer side where it's taken away by this passive heat sink provided by the reactor cavity cooling system for an extended period.

The reactor cavity and its structures will maintain its geometry. In other words, during a safe shutdown earthquake, the reactor vessel will stay in tact. It will stay or so be cooled. The reactor cavity cooling system will still function. And this goes for that third bullet there, the reactor cavity including its structures will maintain geometry during all credible events.

DR. KRESS: Does this heat removal depend on having the helium in place pressure, or how does it work --

DR. SLABBER: Can I explain the reactor cavity cooling system?

DR. KRESS: Oh, sure.

DR. SLABBER: Yes. The reactor cavity cooling system consists of three independent cooling tanks. The ultimate heat sink is the C or air coolers on the roof of the reactor for all three tanks. It consists of two loops each. In other words, the primary coolant flows through a heat exchanger which then dumps its heat into the ultimate heat sink. So there's an intermediate loop.

The cooling system consists of three tanks of 50 percent in the cavity surrounding the reactor vessel. Each tank is 60 centimeters diameter and covers the total length of the reactor core plus an area about 2 meters, 2½ meters above the reactor vessel.

The sequence of events could be seen now during a loss of cooling event in that if for instance something goes wrong in the primary cooling, because primary cooling is done by means of the primary -- the conversion unit. The turbo compressor is running because it's a break in cycle, it's in a bootstrap operation; they must be running to circulate. We've got a -- what we call a starter blower system which must bootstrap the breaking cycle to start off with.

So if something should go wrong and we should lose this cooling loop in the primary circuit to cool the core, because heat rejection is done in the intercooler and precooler at the turbo compressor; If that heat rejection mode is lost, then we've got a core conditioning system which can run parallel to that. And that is forced convection. That's active component. But should that all fall away, then the reactor cavity cooling system will be capable of handling the decay heat coming from the core exactly after shutdown, in other words 1.3 megawatts of heat which could be dissipated to the reactor cavity cooling system.

The reactor cavity cooling system has got a few layers. It's an active system consisting of these loops, the primary loop, the secondly loop which is backed up with the cooler on the roof, and then if that fails, then we go into a boil-off mode and the tanks will boil-off if it's not being replenished by means of operator action. After a couple of days, even, it will boil-off in something like four days.

We believe that operator intervention will take place in that time. However, if that even fails the concrete structures are sufficient to eventually dissipate. Obviously, in such instances, the reactor -- the concrete will be heated up to a value which we are still determining at the moment and we're engineering some methods, but we believe that we will not damage the concrete unnecessarily.

Does that answer your question?

DR. GARRICK: Can I go back and ask a question?

DR. SLABBER: Yes.

DR. GARRICK: Out of curiosity, on the Xenon oscillation issue. I can see with this annular design where you would have good neutron coupling in the radial direction.

DR. SLABBER: Yes.

DR. GARRICK: But it is not so obvious in the axial direction.

DR. SLABBER: We have looked in it because for Xenon oscillations there is a reactor height which takes you out of the safe region of oscillation.

DR. GARRICK: Yes.

DR. SLABBER: And we are still within that limit.

DR. GARRICK: Okay. But there is a limit?

DR. SLABBER: There is a limit, yes.

DR. GARRICK: Yes, okay.

DR. SLABBER: Any more questions?

Next slide. Skip that one. I'll come back to that.

In the German program, the licensing was completed for the HDR model and Xenon's developed a curve which they used to convince the regulators that the reactor is safe from a release point of view, and they generated this curve, and I must explain to you because this curve you might see also in our safety analysis report.

We do not, and I stress do not intend to just follow this slavishly. And I would like to explain this and, please, we must take note of the importance of this. It is so important in Germany that they have coined the word "the holy curve." And they didn't want to deviate from this at all.

Now, what we've got on this axis, we've got the failure fraction of practical and we've got temperature here. And then we've got three lines representing beginning of life, fresh fuel. We've got a life cycle and end of life.

What they've done to develop this curve, they took 212 microspheres to get good statistics and they did, on fresh fuel, they did a burn leech test. In other words, as code fuel freshly produced they just measured the unclad uranium friction by means of a leeching test to see which of these microspheres are cracked. And they found it to be 6 times 10 to the minus 4. That is a very important baseline for them. That is why, yes -- to the minus 5.

What they've done is that they took that and then they irradiated all those 212 out of the same batch, although it was the same batch, they took 212, they took another batch 212; they irradiated it and they didn't find any failed particles, zero. So they were faced with a dilemma how to now extrapolate from that result what is the end of life of failure fraction. And what they then did, they applied Poisson statistics for zero failures at the 95 percent confidence. And they found that to be 2 times 10 to the minus 4. And then they slapped on that some conservatisms and they added that to the original 6 times to the minus 5 and they came up with that 2.6 times 10 to the minus 4.

And then what they did, they wanted to do the same at 1600. They assumed that those values stayed constant, because from a methodological -- the graphical consideration is no reason for disintegration of the cladding between those two values. They extrapolated the same values and they took a sample. And this is where we will be deviating from their approach. They took only a sample of 65,000 and because of the statistics and they couldn't find any broken particles after heating it up, so they just used zero failure statistics and that pulled up because of the uncertainty, the failure fraction to that high values.

We in PBMR are planning to replicate this, but we will be keeping the sample sizes constant. And we expect that our fuel failure fraction will be around 10 to the minus 4, and it will be relatively constant up to 1600.

Can I have the next slide?

DR. KRESS: Excuse me, George. I was surprised to see this as a failure fraction rather than a failure fraction rate. Do you think there is a rate involved here?

DR. SLABBER: Well, what is assumed, and this is also our approach, is that we are not assuming any rates the fusion constant, et cetera, because that will put us in a maze of uncertainties.

DR. KRESS: Yes.

DR. SLABBER: We assume that if the fuel reaches a specific temperature, the content is -- that takes us away from proving experimentally that a certain isotope like silver or cesium or strontium defuses at a certain rate through the microsphere.

DR. KRESS: That's what General Atomics' model does.

DR. SLABBER: That's right. And we believe in South Africa that it puts you in a maze of uncertainty, and we have done the analysis and we have seen that with releases in a big depressurization event, the containment performance -- and I'll come to that a little bit later -- is sufficient.

DR. APOSTOLAKIS: So do I understand correctly that these curves were produced from zero failures?

DR. SLABBER: The rest. That was produced from experimental we determined on means that were done on the leech test. And everything was based on that specific one.

We will be repeating this, but we will allow us to be criticized at every point.

DR. POWERS: I guess what I don't quite follow is that you're testing -- you're assuming that just temperature is the variable. Does that mean that you're not running these fuel particles through operational events?

DR. SLABBER: Such as?

DR. POWERS: Shutdown, restart, abrasion?

DR. SLABBER: No. Abrasion we will be testing in the fuel handling system, the diameter. And if it goes below a certain value and that leaves you a very big margin because thickness of the unclad -- of the unfueled section is five millimeters, we will allow the diameter to go down to 58 --

DR. POWERS: What I'm asking you is there no synergism between temperature, irradiation and fuel motion as well as normal cycling operation on the cool failure rates?

DR. SLABBER: I'm talking about fuel failure rate in terms of microsphere failure rate.

DR. POWERS: Yes, I understand. I understand.

DR. SLABBER: Yes. We believe it's uncoupled.

DR. POWERS: And is there any substantiation to that uncoupling?

DR. SLABBER: Substantiation for uncoupling?

DR. POWERS: Yes. I mean, what I'm really trying to understand is why is it the temperature is the only variable to consider here?

DR. SLABBER: It has found that in the German test that the temperature is the driver of the cracking if there is something. And the manufacturing-- the pressure, though, the ramp rate because the temperature gradient through microsphere integration has not been considered, and it was believed that it's uncoupled.

Next slide, please. The previous -- sorry. The previous slide.

This is a artifact which we have developed from German literature showing, and this is the -- if you noted at this stage that it's showing the tendency, what happens beyond 1600 without saying that this is what we expect, because this was extrapolated back from releases. Real releases back to failure fraction.

Now what is happening here at 1600, the silicon carbide coating on the microsphere slowly starts thinning due to reactions with fission products. And you get this slight increase in failure fraction -- I say you're going this way now -- they look back from a release rate. And then there is a gradual increase, and then at 2200 degrees Centigrade there is quite a gross dissociation of the silicon carbide microsphere coating. And that's the reason for this rapid increase.

So this is silicon carbide thinning and degrading, and this is actually the disintegration. This is the reason why I brought this, because this will also be part of the testing.

Skip the next slide.

Our conversion unit is interfaced in the coolers with an auxiliary cooling system which interface directly in the coolers with a helium coolant. What happens is that the pressure in the primary system is always higher than the coolant in the auxiliary cooling system. So if there should be a leak, the water should leak out into the auxiliary system and there are instruments that detect any leak. If we are doing maintenance on the reactor and the system is depressurized, then there is the only interface with the primary -- with the core is by means of the core conditioning system, which has got a very limited volume of water circulating through the heat exchangers. And then the primary coolant system is always monitored from a radiation point of view to see if there is any contaminants like fission products, especially in this case, moisture and air.

The physical design of the core itself is such that in the event of even a beyond licensing based event, that the establishment of a established flow regime of air through the core is not feasible, but this is being modeled by means of CFD at the moment. We believe we think our difficulty could be to -- and this is also time dependent, and it's got a temperature limit beyond -- 400 degree average temperature, it is not possible even with gross ingress of air. So, it's really an event which gives you time.

Next slide, please.

The physical core design for the prevention of excess burn-up, because a fuel has got a limit and licensed to a limit of burn-up. And we will be licensing our fuel for 80,000 megawatts and it's got that limit. And we will -- the core is designed that a ball could not be trapped like in the German reactor program, there were certain of these spheres that were trapped somewhere in the core, pressed into the graphite for some long time. It did not give rise to a rise in activity, but our core design is such that the flow is so well defined that we do not expect that.

And then we've got on-line spectrometric, gamma spectrometric measurements because we need to evaluate -- is it fuel or is graphite. And if it is fuel, by means of gamma spectrometry we determine if the burn-up has reached the limit or can it be recycled.

So, these are those attributes.

Next slide, please.

So if we now look at the barriers to the environment from the kernels, we have beyond -- before that we've got the UO_2 kernel which provides some degree. I say some, but we do not take credit. And then we've got the three -- the pyrolytic graphite, we've got the silicon carbide and we've got the other pyrolytic carbide. But credit is only -- we're looking from a qualification point of view only at the silicon carbide. We listed those three layers because that is the reality.

And then we've got our high integrity primary pressure boundary, and we are learning and we're using information from the light water reactor people which has developed materials, steels, et cetera, and we try not to deviate from that developed and evaluated envelop.

So we will be using pressurized water reactor reactive pressure vessel and the pressure boundary we will take note of developments.

And coming to the containment, which we have been defining in the past, and it's a debateable question, as confinement but we are using the term containment. But at this stage let me just explain to you what is happening during a event when release takes place.

You get a rupture of the primary pressure boundary, and we've got 10 millimeter breaks analyzed, we've got 65 millimeter because that is the size of the fueling tube. And then we've got big breaks like the control rods or the bottom unloading shute or the PCU pipes. And we've got graded pressure releases. And for each of these we've got a system, a pressure release system by means of ruptured panels which release from specific cavities in the containment to a pressure relief stack which automatically opens and closes again after this puff goes out. And then it's got a backup which could be closed if it does not close automatically by an operator.

And then if there's an excessive event like a 10 minus 6 and lower event like the rupture of the big manifold pipes, in addition to this pressure relief, there are -- if we think back to the first slides of the building that can lift up above the PCU and release into a big plenum. And then if the pressure is still in excess, panels will blow out, but remember, of the wall. But remember this is an analyzed event.

The containment is designed to relief through the pressure relief stack and be closed automatically with operator backup. So we define for the performance requirement that we need this containment has a high leakage vented containment, because we've got also the HVAC. And the HVAC is also automatically closed off during such a depressurization and could be opened again later to filter light releases at a low pressure.

So we've got a concrete structure which is a citadel, but actually it is high-leakage vented containment. We've got a filtered vent path for later releases. And we've got hold up of fission products in plate out in the system, et cetera, which is not lifted out. And the auto-close blowout panels. And then we -- by means of this HVAC later releases from these particles if there are any additional.

Thank you.

Just coming back to the nonproliferation aspects.

Mr. Chairman, I'm sorry, I'm taking a little bit longer.

There is a number of attributes. It's a closed -- it's an on-load fueling system. The IAEA can install flow monitors to see where fuel is and track the fuel movement. And the burn-up is 80,000 megawattage per ton which gives a plutonium mix which is very unfavorable for weapons manufacture. And then the fuel produced during the operational time of the reactor is all stored in the facility under the surveillance of IAEA.

DR. POWERS: It seems like it's a design

that's well suited for producing 239 because of the on-line fueling/defueling at the facility.

DR. SLABBER: Yes, it is. But if you look at the amount for even the first cycle, you must divert about 212,000 spheres continuously out of your system to produce a favorable mix. So what we have during a ten cycle, which is from a -- point of view, the optimum at the moment we're thinking about five, it gives some problems -- not problems, but a higher flux higher up in the core. At discharge the mix is 66 percent 239 and compared to either --

DR. POWERS: Change your cycle. Lots of 239 --

DR. SLABBER: You need only one force of fuel sphere to give you a very small -- and you've got to take them all out into the diversion path. And this is not difficult to detect.

MR. SPROAT: Thank you, Johan.

What I'd like to do is just briefly close and address the issues. So now you understand a little bit about the technology itself and the preliminary design of the PBMR itself, what about getting it licensed here in the U.S.?

As part of Exelon's decision making process, we are currently evaluating and doing a license ability assessment on the PBMR. And I want to talk about very quickly the key issues that we see both technical and nontechnical.

And on the technical side, obviously right now most of the regulations existing in the U.S. are focused on light water reactors. And if we were to come in today with an application for this technology, the NRC reviewers would sit there and they'd use what we call the "two finger approach;" one finger on the regulations and one finger on the submittal and say "Okay, how did you meet this, how did you meet that?" In some cases that'll be very appropriate and in some cases it won't be appropriate at all given differences and uniqueness of this technology.

So, working with the NRC staff over the next 18 to 24 months, we hope to develop a regulatory framework that they can use and that we can use to design against, they can to review against so that we've got a credible regulatory framework that we can try and license the PBMR with if we go forward.

The second area is fuel qualification and testing. Johan talked about that. The key thing about the fuel is that, you know, this isn't new. You know, trico-coated practical fuel was used back as early as 1967 in the dragon reactor in the U.K. So there's a great body of information out there. We need to be able to tap that and use it as part of our licensing basis and not have to reinvent the wheel.

But the other aspect of this is the first fuel loads for the PBMRs in the U.S., if we do go forward, would come from South Africa. So the role of the NRC in reviewing that fuel plant down there and licensing it or not licensing it but certifying the end product for use in a U.S. reactor is a whole area that we really haven't explored yet and will need to be addressed.

DR. KRESS: When you talk about fuel quality, are you talking about that fraction of particles fail versus temperature curve?

MR. SPROAT: Yes. Knowing how the fuel will react under various conditions that's consistent with the safety case for the reactor licensed in this country.

DR. KRESS: Does that include any trapped uranium that might get trapped in the --

MR. SPROAT: Yes, obviously the test program takes a look at what the -- not only what the failed fuel fraction is, but also the trapped uranium that's on the outside of the particles as a result of manufacturing process.

DR. KRESS: You have a goal for how many particles can be failed within the core before you violate 10 CFR 100 --

MR. SPROAT: I'm not sure we're that far along in the analysis at this stage of the game.

DR. KRESS: Okay.

MR. SPROAT: Clearly an issue that we're going to have to wrestle with the staff, once we decide ourselves how we think the appropriate way of addressing it, is what's the source term? Is it mechanically mechanistically determined source term or deterministically determined source term --

DR. KRESS: Well, it's the answer obvious there?

MR. SPROAT: Pardon?

DR. KRESS: Isn't the answer obvious there?

MR. SPROAT: No, the answer's not obvious. I know what we would like to do, but the issue of how good are your goods analyzing your diffusion coefficients and being able to provide an analytic framework for migration of fission products from the core to the environment is going to be a challenge. It's going to be a challenge.

Obviously, containment performance

requirements, Johan talked about the containment design and whether or not a zero leakage or a LWR type containment would be required versus moderate to high leakage filtered containment would be required is obviously an issue that's going to be discussed at some length.

DR. KRESS: And that would be linked to the fuel quality?

MR. SPROAT: Absolutely, and to the source term.

The issue of the various computer codes that are being used in South Africa to design this plant, how they're verified and validated and how they're benchmarked against the other existing codes will be an extensive effort associated with that.

The PRA itself that's being developed in South Africa that we're advising them on, it's kind of interesting. You know, if you have -- what's your endstate if core melt isn't a valid endstate for your reactor? And what is your endstate? What are you initiators and how do you determine your uncertainties of your various accident sequences?

DR. KRESS: Your endstate is quantity of fission products. Frequency of fission products.

MR. SPROAT: It might be. But the point

is that we're exploring some new ground here and, obviously, there'll be some discussions with staff about how we go and do that.

The regulatory treatment of nonsafety systems and how we classify the SSCs, the safety system components, will really be a key issue.

And then finally, an issue that I lumped in the technical area, but it's a real practical issue is there aren't a lot of people left in the U.S. in the NRC, in the national labs or in DOE that have gas reactor experience and understanding. And so, obviously, I think you've gotten a sense as we go forward with this, if we submit an application having people who understand the technology, understand the science and can provide good independent review of the submittal is going to be a real challenge.

On the last slide I have is the nontechnical, what I'll call the legal licensing challenges. And I personally believe we have a very good chance at satisfactorily resolving a number of the technical issues that I showed on the previous slide. I'm not as confident about some of these, because some of these are potential deal breakers for moving forward with merchant nuclear power plants in this country. And that's what we're talking about here; this is not a power plant or nuclear plant that's going to go into a rate base somewhere. This is a merchant plant where the shareholders are going to take the risk of building and operating this plant and whether or not it makes money in the deregulated marketplace is solely dependent on the technology and the company that runs it.

So, the first issue up here is Price Anderson. The current law and the way it's currently interpreted by the NRC is that each reactor in the country is assessed a retrospective premium of $90 million per reactor in the case of an accident anywhere in the U.S. associated with any reactor. Well, if I've got a 2200 megawatt light water reactor plant, like our Limrick plant, that means my retrospective premium at risk due to a reactor accident somewhere in the U.S. is $180 million retrospective premium associated with that plant.

If I have the same capacity of pebble bed modular reactors under today's law, my retrospective premium would be $1.8 billion for that same amount of capacity. Even I would have difficulties selling our board of directors to take that kind of a risk associated with that kind of retrospective premium associated with an accident from a reactor that we don't own or operate. So that's got to be addressed somehow.

The second issue up there is the NRC operational fees. Right now the operational fees are approximately $3 million per reactor. Again, say at our Limrick plant, that means about $6 million a year for the two reactors. The same size for 2200 megawatts, you're talking about $60 million a year in NRC licensing fees for a 2200 megawatt set of string of PBMRs. Really excuse the economics of a merchant nuclear plant significantly.

The decommissioning trust fund is another issue that's clearly going to have to be addressed. The law gives a number of different alternatives, but those alternatives have presupposed that generally the plant is going to be operated by a regulated utility and that in the rate base in which the plant is based rate, you have a set aside income stream that goes and funds the decommissioning trust fund. In our case that won't be the case. These plants won't be in a rate base. How we fund the decommissioning trust fund, how much we have to put up front and what we can put into a sinking fund needs to be resolved. The law is not clear on that at this point in time.

Clearly, Part 52 licensing process which is, we think, the right way to go is untested at this point in time. Nobody's actually done it. So the staff will be learning, the applicants will be learning, and how we actually work our way through that and how long it takes is going to be a key challenge for us.

And then finally, I have up there up the potential number of exemptions. As I talked about earlier, there is no gas reactor licensing framework. And if there's not when we go with an application, the staff might decide that a number of the things we're asking for are very appropriate to license this plant, but will require exemptions from the existing regulatory framework. And, obviously, it would be undesirable to all of us to have the first advanced reactor in place with a significant number of exemptions. It just doesn't work.

So, those are the key issues and challenges we see on the licensing side, both from the technical side and the legal side. And, as I said, we are considering all that and now we'll go into our decision making process as to whether or not to proceed with both the venture in South Africa and the licensing process here in the U.S. by sometime around the end of the year.

DR. KRESS: These appear to me like mostly policy issues rather than technical ones related to the reactor design?

MR. SPROAT: A number of these will require some policy statements and decisions by the Commission itself, yes.

DR. KRESS: Very good. Is there any discussion or questions for either of our two speakers?

DR. APOSTOLAKIS: Yes, I have a question. As I recall in one of your communications to the staff in addressing these issues, the key legal licensing issues, you proposed that a site with ten units be considered as one reactor?

MR. SPROAT: One facility.

DR. APOSTOLAKIS: One facility.

Now, if this is accepted by the staff, then should we also be applying the same idea to various safety goals and say, assuming that the concept of core damage makes sense here, that if the goal is 10 to the minus 4 and that would apply to the facility, so each unit then would have to ten to the minus 5. And given the fact that you have ten of them, you have some synergistic effects, maybe it'll have to be even lower than ten to the minus 5.

MR. SPROAT: Well, synergistic effects is not intuitively obvious to me that there are synergistic effects when in fact the risk from one reactor to the other. I'm not ready to concede that point at this point.

DR. APOSTOLAKIS: Okay. Fine.

DR. KRESS: Some common mode.

DR. APOSTOLAKIS: Some common mode, perhaps. Anyway, but I mean how about the thought process here that you would apply stricter criteria --

DR. KRESS: Yes, instead of calling it core melt, call it fission product release --

DR. APOSTOLAKIS: Call it something else. Yes, fission product release.

If we treat 10 PBMRs as one facility with respect to these five bullets that you showed us, shouldn't we be doing the same when it came to risk and treat it as one facility and apply the goals to the facility, in which case of course we will have much lower goals for each individual unit?

MR. SPROAT: Well, we certainly haven't done that for two and three unit light water reactors. So, I hesitate to do that for a smaller, supposedly safer reactor.

DR. APOSTOLAKIS: Well, safer of course is something that you would approve of.

MR. SPROAT: Sure.

DR. APOSTOLAKIS: But for a two unit reactor there are some PRAs where they look at these things. But a factor of two in the goals really doesn't mean anything. But when you talk about ten, a factor of ten, then you're beginning to see some difference.

So it seems to me that if we are to apply this idea to the five legal licensing challenges you mentioned, maybe we ought to think about doing the same thing to the goals. Now, you don't have to answer right now, but --

MR. SPROAT: I would probably disagree with that, but that's okay.

DR. POWERS: Explain why you would disagree other than the fact that you wouldn't like the numbers when they came out.

MR. SPROAT: No. What would the basis be for doing that? For example, in airline travel there's a certain risk associated with flying on an airplane. Now, the fact that there are increasing numbers of airplanes in the air doesn't necessarily mean that your risk of being killed on an airplane has proportionally increased.

DR. APOSTOLAKIS: The societal risk has.

DR. POWERS: Right.

DR. APOSTOLAKIS: The individual risk has not.

DR. KRESS: You don't fly the same number of people on the airplanes. What you have is a site with a given fixed population around it, for example. And that population is exposed to either one module or ten modules who could fail independently of each other, and in fact that's probably the assumption. But the risk of being on that site and associated with those reactors is, in my mind, ten times when you have ten modules over one module.

DR. POWERS: Tom, isn't it even higher than that because you've got a mode failure with the--

DR. KRESS: Yes. And then if there's common mode failures, it's even higher.

DR. POWERS: Especially if you go up --

DR. KRESS: And that would be the reasoning behind --

DR. POWERS: -- to a centralized control room?

DR. KRESS: Yes. So you treat it as one reactor, but in order to accommodate the ten of them you have to do something to one end; you either up the frequency by ten or the lower safety goal by --

MR. SPROAT: Well, then clearly you have to take into account in that kind of an analysis the concept of coincident events happening in multiple units at the same time.

DR. KRESS: No, no, that's not --

DR. POWERS: It's just common mode failure is what we are talking about here.

DR. KRESS: But that's not what I had in mind.

MR. SPROAT: Assuming there is a common mode failure that --

DR. POWERS: But that's not what we're saying.

DR. KRESS: Yes, but that's not what we're saying. I mean, that's another issue, coincidence events and common mode failures. No, I'm not just talking about an independent frequency of something happening to one or something happen to the other independently.

DR. SHACK: Of course, now he does get something back because he probably has a smaller source term.

DR. KRESS: Oh, I think that's a -- for this concept, that's --

DR. APOSTOLAKIS: I didn't say anything about the assessment.

DR. KRESS: Yes. He said --

DR. APOSTOLAKIS: I'm just talking about the goals.

DR. KRESS: I'm sure they could meet the ten times or the ten percent --

DR. APOSTOLAKIS: You don't use a facility of ten PBMRs only on these things. I mean, and the goals have to be reflected.

MR. PARME: George, I might add in the mid-80s submittal on the MHTGR where there were multiple reactors coupled to a common steam plant, it was viewed as a plant and we took the safety goals and the release limits that we were analyzing it and considered multiple reactors. And, in fact, if you look back in the mid-80s submittal you'll see there is at least one event that has all four MHTGR models leaking simultaneously without cooling. And it was handled that way.

It's not quite the case where his reactors are truly independent, but we did consider the four modules to be a plant consistent with your thinking. What you would do with truly independent modules, I guess, is something that one might want to think of.

DR. APOSTOLAKIS: If we decide, for example, that as we were saying earlier that the appropriate way to look to formulate the goals here would be through frequency consequence curves, then it seems to me that you would have one such curve or a family of curves for the facility.

DR. GARRICK: Yes. Well, why wouldn't you have a CCDF for the facility?

DR. APOSTOLAKIS: For the facility, that's what I'm saying.

DR. GARRICK: And every time you add a module, you get a new CCDR.

DR. KRESS: Yes, absolutely.

DR. APOSTOLAKIS: Yes.

DR. GARRICK: Yes.

DR. APOSTOLAKIS: But the goal would be one. And then what you do under it, you know, assuming you're acceptable is your business.

DR. GARRICK: Right.

DR. APOSTOLAKIS: Anyway, that's just a point.

DR. KRESS: But it's a thought.

MR. SPROAT: Understood.

DR. KRESS: Other questions? Okay. Please use the microphone and identify yourself for the record.

MR. GUNTER: Paul Gunter, Nuclear Information Resource Service.

Obviously fuel integrity is a big question here. And what I would like to get a little better idea of, is have you looked at the THTR that was a 300 megawatt PBMR in Germany? I believe there was an event there on May 4, 1986. And I'd like to know what your assessment is of the fuel failure mechanism that occurred there?

DR. SLABBER: I do not have at this stage information about that specific occurrence. But what I can tell you is that due to the uniqueness of the THTR core where they had control rods and shutdown rods of this size pushing vertically into effect pebble bed during shutdown, that caused some of the pebbles themselves to break, although no evidence was ever found that they found loose coated particles somewhere in the fueling system. But that gave rise to a bigger than normal fuel sphere breakage, the specific design itself.

MR. GUNTER: It was the graphite that broke apart or was it the pyrolytic coating that broke?

DR. SLABBER: It was the graphite, the

matrix that kept all these coated particles in a configuration.

MR. GUNTER: Right. So just for my understanding from what I've been able to ascertain is that the fission products are to be retained inside the pyrolytic coating, though?

DR. SLABBER: Inside the silicon carbide.

MR. GUNTER: Right. So if there was a -- so it would seem like there was some kind of failure mechanism on that pyrolytic coating as well. I mean, was the coating crushed as well as the graphite sphere?

MR. SPROAT: What we know from that event, and I haven't gotten all the details of the German government review, is that as Johan said that the pebble bed that's in the THTR in Germany had its control rods inserted directly into the pebble core. That broke a number of pebbles. So and then when they tried to come out through the bottom for the fuel handling system; if the ball's round, then it goes through the system really well. If it's broken into pieces, it gets stuck. And evidently what the German operators did is they found they had some broken and stuck particles -- not particles, but pieces of the fuel spheres in the handling system that got stuck, and they had to clear them out of there.

MR. GUNTER: And that was done with back pressure of helium or --

MR. SPROAT: Well, I know that back pressure of helium is one of the methods they used to clear some of that fuel handling system, but they also I think in that case you're referring to is they used some mechanical force where they tried to either hit things with either hammers or with rams to free that piece. And it appears what happened in that case is that a number of the little particles from that mechanical impact were ruptured, and that released some of the fission products from inside the spheres. But it was basically mechanical damage to the fuel particles itself due to operator interaction.

MR. GUNTER: Okay. If I could ask one more question. It's also my understanding that the Germans abandoned the technology because of problems with quality control on unused fuel. Have you looked into that as to what the failure mechanism was for the unused fuel?

DR. SLABBER: The only records we have is that the German program would have continued, but there was some other political pressure to terminate any further investigations. But the database that we have access to do not address any of such problems that you're highlighting now. In fact, they have still available for evaluation some of their unused fuel spheres and we intend to do some pre-irradiation evaluation of those spheres.

MR. GUNTER: Of course, if there was evidence of damage to unused fuel, you would be interested in seeing that

DR. SLABBER: Of course, yes.

MR. GUNTER: Thank you.

DR. SLABBER: Can I just make another comment. The design, the German design which had the control rods in the bed directly in the core was one of the reasons why pebble bed design deviates totally from that design. And the decision was made, control rods only in the reflector, sides reflector.

DR. KRESS: Okay. I'd like to move it on because we are running behind now, and move to the next topic, which is, I believe, the IRIS by Westinghouse representatives.

MR. CARELLI: Good afternoon. I'm Michael Carelli from Westinghouse Science & Technology Department. And among the many things we do is the leading edge support of the business units, also heavily involved in Generational IV reactors, and especially on IRIS.

Now, I have to tell you a couple of things before I start. And the first one is you have in the passouts some viewgraphs that aren't exactly right.

Last week I at IA meeting in Cairo and I was trying to do very much control. This presentation is terribly efficient. But we have the right package, and if you need it you see me and I'll get you a copy.

And with that, I think my time is up now, right?

DR. KRESS: Yes.

MR. CARELLI: Okay. Nice meeting you.

Okay. IRIS. Can I have the next one? IRIS is International Reactor Innovative and Secure and the key word there is international, and you'll see in a second why.

If I can have the next, please? I'll try to move fast as I can.

Is the new kid on the block. We've been in business for about 18 months, so what you see is about we started at the end of '99 this work, and so in trying to compress in about a half of hour the work we've done on a new design, I had to skip a bunch of items. And I'll be happy to answer and expand them during the session this evening. So right now I try to kind of streamline on the key things and then hit the issues, because for this new reactor thing that's what you want to hear most.

So I'm going to have a brief overview; our team, the funding, the objectives. I'm going to tell you about a few designs. It's plural, it's not a typo. It's few designs, plural. And then the configuration of the integral vessel. And I'm going to spend quite some time -- well, "quite some time" relatively speaking on the safety design because I think that's kind of a trademark of IRIS. They approach the safety we have together with the maintenance optimization. These are the two things IRIS, I believe, does different. And then, as I say, I hope to spend some time talking about the issues.

Let's move to the next one, please. Overview, keep going. I have a bunch of fillers. At least you know where we are.

Okay. This is a capsule on IRIS, just to give you a kind of best view what the reactor is. What you have on the right is an earlier version, it's 100 megawatt electric that we designed until around December of last year. It's an integral system. Integral means everything is inside the vessel; steam generators, clamps, pressurizers -- pressurizer, singular, is inside the vessel. Is integral, integral configuration. And it has a lot of advantages. It is really an excellent configuration for safety and we're going to touch on that, as a straight bell core, no shuffling to refueling. You put the fuel in, take it out at the end of life.

And we have two designs for five years, an ATS lifetime. And you'll see in a second, in a couple of seconds.

It utilize LWR technology. In the new engineering burnt is a proven technology. This is a key point when you look at development schedule, this is a new engineering. We are not demonstrating a new technology. Also the integral configuration for the light water reactor is not the first time. There is a surface ship in Germany has been running along the seas with an integral reactor like this, and of course all of you know the submarines, they are running on that. And also there's been experience -- on integral reactors.

Safety is and most action initiators are handled by design. And I'm going to go into safety by design issue and what we do -- we do on that.

Potentially the cost, is the cost competitive with that options both in nuclear and non-nuclear and the development, the construction, the deploying and everything from the very beginning is by international team. This, by no means, suggest Westinghouse -- this international team that is designing IRIS.

And we are projecting the first module deployment in the 2010-2015 time frame. 2010 is kind of widely optimistic, 2015 is probably conservative. And this morning you heard about 2020/2012, and this is about the time I think we are targeting.

The way IRIS started was in answer to the Generation IV RFI that we had from DOE. And basically we were trying to look at satisfying the goals of safety and unsafety, sustained development.

What you have on the left are the various design features of IRIS, and you can read. And basically what we found that those design features, the way we started the design, was they were to satisfy safety and to satisfy the waste minimization issue. And then we found that every single one also has a positive effect on economics.

Next slide. Thank you. So I said every single one does end up on the positive column of economics. So at that point to say, gosh, you know, we had quite a good design for commercialization.

And, please, the next one. And that basically what happens. And what happened was that we started building a consortium of organizations where they're interested in joining IRIS. So the first thing we did was to have a colorful logo, and then after that we went to work.

Next one please.

DR. KRESS: Is that Latin?

MR. CARELLI: Yes, that's Latin. From the Italian, what do you expect? This is a Latin motto, and I think even the translation has to do with nonproliferation. Believe it or not.

So what we did, we had the initial team was from Westinghouse, two U.S. universities, California Berkeley and MIT, and from Milan. We wanted the work published. We started having phone calls other people wanted to join. And what you have here is chronologically. This is the organizations that joined IRIS in time.

At the beginning, it was mostly development. Then what we did recently in the last few months, we added an organization as a supplier site because we had the design that is moving very well along. Now who is going to fabricate, who is going to be the manufacturer and so forth? So we have additions to the size -- which from the very beginning, an addition like Ansaldo, Spain and Brazil to do the components.

And now what you see now is that we have also team members from developing countries. IRIS is very attractive for developing countries and, in fact, I'm coming back from Cairo and had a very, very good reception from developing countries. It's 100 to 300 megawatts and it doesn't clog up the -- of developing countries like 1,000 megawatts does, so this is quite attractive. Next please.

Now, you heard the question this morning, John. It said what is a dedicated enthusiastic team? Yes, you have. You have a dedicated enthusiastic team that's designing IRIS and it's very enthusiastic that this is the money we're getting from the UE. This is the money over three years from Westinghouse, California Berkeley, and MIT. This is the money that the other participants are putting in on their own. This is in kind contributions. People they're putting to work. They're working on. Right now we're running around this. So that's enthusiastic when you put out that type of effort. Next.

Okay. One of the questions was what's the schedule? The schedule was at the end of the first year, this is the end of our first year of life, we wanted to assess the key technical and economic issues. Basically rather than going through the old thing, we just pick up the key issues and resolve them, and we have done that. Right now we're filling in the blanks. We're doing the conceptual design and the preliminary cost estimate and at this point is the end of the NERI grant in 2002. At that time, we're going to have the preliminary design completed, the preliminary cost estimate completed. Sometime in between now and then there is the pre-application submitted to NRC. We're in the preliminary stage now, we have been talking with the staff a few weeks ago. I'm talking with you now and it's in the process.

I put a question mark because really I can't say it's going to be July, August or so. But it's going to be definitely soon that we're going to talk.

Now here is where lightning is going to strike. At the end of the first three years, the consortium is going to sit around the table and say, okay, now we have a design, we have a market, are we going to proceed with commercialization? Right now every indication is that the answer is yes but at that point then it goes on a quantum step in terms of effort. It's no longer $8 million or $12 million. It's going to be quite a lot more. So if that happens -- right now, of course, we're not doing this for the fun of it. We are working assuming that is going to happen.

Then our schedule calls for a complete SAR by 2005, design certification by 2007 and first-of-a-kind deployment beyond this. And I'm going to have some discussion on these dates at the end. Next please.

DR. KRESS: Would your SAR follow the SAR process that we use now for light water reactors?

MR. CARELLI: Yes. When the issue is safety, I think it should be simplified. Should be a simplified SAR. We'll see.

Okay. Here now the cores. Originally we worked on this. The proliferation resistance -- the idea is you have a core and you put in no shaft and no refueling. The host country doesn't have access to the fuel. The longer you keep there, the more proliferation resistance you have. So we found that eight years we could have burn-up around 70,000 - 80,000 and we worked two designs with UO_2 and MOX interchangeable so essentially with the same IRIS design exactly the same, you can put whatever fuel core you want. So that's what we have done.

But then what you have, you have IRIS requires eight percent enrichment. Right now we don't have a licensed eight percent production facility and we don't have the database for the burn-up and so forth of the eight percent. What we said at that point, we say why do we want to complicate the life and let's say the first core with a five years design, same thing straight through for five years, same principle, nothing different. But this is 4.95 percent enrichment.

Our facility in Columbia can fabricate it to model as exactly the same design and the same configuration as the PWR assembly. So if you say that you can't recognize the difference between a regular PWR and an IRIS assembly.

It's well within the state of the art because the average burn-up we're projecting is around 45,000. So at this point with this we have taken out completely any licensing issue because this is a PWR assembly. The only thing we are doing different, instead of shuffling every three months, we let it cook for five years. That's it.

At the same time, we are going to look at this and we have here our university team members that keep working on this and we're going for the licensing extension while we're working on and eventually we ask for licensing for this in the time frame of 2015 to 2020. So right now I want to say this is the IRIS core. That's what we're focusing now. Next please.

The configuration. This is the 300 mega version, 335 actually. You see here is the steam generator and this is different from the pass outs because in the last couple of weeks we changed the pumps. What we have now, we have a pump which is called a spool pump is inside the vessel and there is no penetration. The only thing it takes is a couple of inch line for the power, and that's about it. It's already inside the vessel, high inertia and actually I was told this morning there has been examples of this with insulation. It doesn't even need cooling.

Now, the point is why we didn't have this in regular reactors. Why this coming out of the woodwork for the first time? And there is an answer. This pump works with 18 PSI head and in present loop reactors you never have an 18 PSI. In IRIS with the very open core and the open configuration we have, our pressure drop is less than 18 PSI. So in IRIS we can take advantage of this thing, eliminate the proliferation device and all of the stuff associated with the pumps, LOCA -- and so forth is all gone because we have a design that can take advantage of this. I think IRIS take advantage.

These here are internal shields. What you have here, you have here the core, here the steam generators and you have a design rate of nothing. If you put shields which doesn't cost much, just a bunch of plates maybe with some boron carbide or even steel, whatever. Next slides, please.

This is what you have. It's a gift of the integral configuration. You get busy for free. The rate outside the vessel is this. Is nothing. You can touch the vessel. The vessel is cold. It has two advantages. One, if you had to send the workers in the containment, you don't need to put scuba diving on them. They can go in there in t-shirt because there is no radiation outside the vessel. The other thing is simply -- decommissioning because you take out the fuel and everything inside the vessel remains there and the so the vessel is like a sarcophagus and this is especially important if you want to deploy IRIS in developing countries. You take IRIS in. At the end of life, you take it back. And there is no decommissioning, no cost left in the host country. Next.

DR. KRESS: When you change out the core, do you also change out the steam generator?

MR. CARELLI: No. I'm coming to the steam generators. The steam generators, what we have, we have this nice lady which you can see, but is in Italian, and this is a picture at Ansaldo. Ansaldo built the helical steam generators for Super Phoenix and they tested the steam generators and this in fact is a huge steam generator. I think it's a 20 megawatt -- steam generator. They tested it. In next slide I have what they tested. But what I wanted to give you here because the steam generator, the perception is we have so much trouble with steam generators now. This crazy guy wants to put the steam generator inside the reactor and this makes even worse. And there are things you have to think.

First of all, if you put a steam generator inside, now the primary fluid is outside the tubes so the tubes are in compression instead of traction. And so now you don't have any more of the tensile distress, corrosion, so forth. Our IRIS doesn't have a bottom so the chemistry is much better. Okay. The other thing is you don't have -- so the bottom of the deposit of the steam generators is the bottom of the vessel. So there are a bunch of things that the steam generator has a different environment in an integral reactor versus a loop reactor. So don't think I have all the problems of the loop, I am compounding them. This is a different animal. We're talking different animals.

Now, what they did in Ansaldo, they tested the steam generators. Next slide, please. First of all, there is experience with Super Phoenix and the MFBR experience. In terms of LWR, as I said before, the auto-on was running on helical steam generators. The one you just saw in the picture before. So they fabricated, tested, they confirmed the performance with all the performance we have and by some stroke of luck, our device is such that we can put eight steam generators practically identical to the models Ansaldo has fabricated. So now we have one thing and that thing is important. What we have now, we have eight steam generators for 300 megawatts. So we're not talking redundancy. That's exactly what we want to do because the steam generator have a very critical safety function and you are going to see in a second what it is.

Next. That's the safety by design. Next, please. Okay. Now on the safety by design. Just doing a little bit of background. The way we see on the philosophy. You take a Generation II. You have an accident and you have cope with active means, like you have a loss of coolant accident and you dump -- emergency coolant system and make up water, all that. On Generation III you do the same thing like you do with passive means. So inertia is going to help you. But still you are doing something to handle the consequences. On Generation IV what we looked at is rather than coping with the consequences, since we have this new geometry, let's take advantage and prevent the accidents through safety by design. Next, please.

And that's basically what we've done. We spent quite a long time looking at the integral configuration and saying how can we exploit this? How can we exploit the IRIS characteristics which is the integral configuration long-life core to eliminate the accidents from occurring. Number 1. Two lessen the consequences and three, decrease their probability. Next.

DR. APOSTOLAKIS: If you physically eliminate the accidents, aren't you decreasing their probability?

MR. CARELLI: No. No, no. Yes.

DR. APOSTOLAKIS: Are there different

accidents?

MR. CARELLI: That's different. Go back. Could you please go back.

DR. APOSTOLAKIS: I understand.

MR. CARELLI: What I'm saying is that of course the first thing you eliminate. You do that. Fine. End of the story. Second, if you can not do that, you decrease -- you lessen the consequences. Fine. If you can not do that either, you decrease the probability. So this is a kind of -- Next.

What we did, this is the one, we're not passing out -- kind of messed it up and I'm not going to this in detail because otherwise you're here until midnight. But what we have on this column is essentially the design characteristics. These are all the design characteristics of IRIS. Just look at the geometry, long-life core, all this stuff. Then I say here what is the safety implication of this design characteristic? Okay. I can't read it. This is -- and what happens here?

Now, the first thing is the most obvious. You don't have the large LOCAs and it doesn't take much -- you don't have any piping going from the vessel to the steam generators, so no piping, no large piping, no large LOCA. That's obvious. Everybody does that.

But then we went to other steps and one thing that we worked on, and I think this is something that is interesting, is the small LOCAs. I still have the two inch pipe break, could have, and historically the large LOCA has never been a problem. All the problems came from the small LOCAs. Next. Sorry. Before doing that, out of that table we said, okay, what happens now to the Class IV accidents that were handled for AP600? And we look with the IRIS approach of safety by design and we can eliminate the LOCAs. We can eliminate the range of the actual accident if we put the control rods and CDRMs inside the reactor because then you have nothing to shoot out.

And all the others really, because of the combination of the integral configuration, the steam generators in compression, all this stuff, could be reclassified as a Class III. The only one we have left is the refueling accidents. It's still a Class IV but the probability is between one-third to one-fifth less. So that's what I'm saying here. First you say you eliminate, then you lessen the consequences and, for this, you lessen the probability. So essentially out of eight Class IV accidents of AP600, with IRIS you're left with one and even that one with less probability. Next.

DR. KRESS: But you're only going to handle this fuel once every eight years.

MR. CARELLI: Yes.

DR. KRESS: Doesn't that give you an additional margin, rather than just this one-third and one-fifth lower probability. The time gives you much less risk due to fuel handling because you're not doing it as often.

MR. CARELLI: Yes. The other thing, too, and as I said, I didn't want it to stretch, but the other thing, too, when you're fuel handling, you start moving things around. You move this assembly from here to there and you drop one or drop the other one and so forth. In the case of IRIS, you don't move anything. You take the old tank and the block -- not the full tank. We try not to move each assembly at a time because they are pressure resistant, we like to have them in big chunks. So you can count. Big chunks.

So then you don't move one assembly at a time. You move chunks. So as you said, you're absolutely right. Reduced probability even more. I think I had a very good story so I didn't want to really stretch it any further. But it is.

On the containment. This is the best part. The containment we have, first of all, it performs a containment function like every good natural containment. But we're doing an additional thing. Since we have the containment, we make the containment working together with the vessel to essentially eliminate the other LOCAs, the small LOCAs. So the small to medium LOCAs in IRIS are gone.

Now, how that comes. If you think why you have a LOCA? You have the vessel and you have a break and you have high pressure here, low pressure here, and that differential pressure drives the coolant across to the hole. Right. Now, if I decrease the pressure in the vessel and I increase the pressure in containment, I have a zero delta P and nothing comes out. And that's exactly what you can do in IRIS. First of all on the containment. We can increase the pressure because we have a smaller containment. It's about half the size of AP600 which gives a factor of two on tensile stress. It's vertical which gives another factor of two.

So now we have a factor of four. So for the same thickness, for the same stress, you can have four times the pressure in IRIS that you have in AP600. Increase the pressure in the containment.

In the vessel what you have, you have, first of all, a larger volume which means less pressure. Also you have heat removal from the steam generated inside the vessel which means a lower temperature. So higher volume, lower temperature means lower pressure. And that's exactly what happens. If I can have the next one.

These are the pictures of the containments. These are pictures inside the containment. This is IRIS containment for 100 megawatts, this is the IRIS containment for 300. Three hundred is about the maximum size you can have with IRIS. You're not going to see an IRIS of 500 because there is a point where the thermodynamics breaks and 300 is about the largest size you can go. Next.

DR. KRESS: The trade-off on having the smaller more compact stronger containment is you have to pay more attention to the normal leakage rates through penetrations?

MR. CARELLI: In the containment?

DR. KRESS: Yes.

MR. CARELLI: Yes. That's what we have to look at. And again, it's high pressure containment. Yes, that's something you have to look at. But the economics is terrific because you have much smaller -- and besides, besides the economics, with our containment, it chokes off the LOCA. That's a key thing.

What we have done to prove that, we have performed an IRIS with different break size, different elevations, and this is no water make-up, no safety injection, and we ran three codes. That's the beauty of having an international team. We ran one at Gothic, at Westinghouse, one by POLIMI, Milan and we provided code and there was one at University of Pisa, FUMO. All three codes predicted the same results. Next one.

This is the pressure differential across the vessel. What happens is after the first quick build-down, for about an hour in the early part of the transient the pressure in the containment is higher than the pressure in the vessel because I'm removing heat like hell inside the vessel while the containment is cooled by air. And so essentially containment temperature goes up. So essentially the pressure and containment is higher than the pressure in the vessel and actually the steam condenses and is pushed back through the break. This is kind of quick. Okay. I'm not counting on this but it's kind of quick for the

100 megawatt, actually for a part of the transient. You have a coolant going back into the vessel.

But the bottom line is the next one. This one shows that after two and a half days this is the level of the water in the core with a 4" break, 12 1/2 meters high, which is the worst place where you can have a break, and we didn't do anything. No core make-up, no emergency coolant system, nothing. In fact, IRIS does not have an emergency core cooling system. What we have in IRIS, we have a bunch of tanks which are used as pressure pools because you have to keep essentially the pressure in the containment up to a point and those, if necessary, can be used for core make-up. But this analysis was done without a core make-up.

So the 72 hours essentially for the LOCA in IRIS, it goes and you do nothing. So I think we have a very good study in terms of LOCA. So for all practical purposes, LOCA for IRIS are gone. The next one.

This is very important because there is people still that doesn't know what are the advantages of an integral reactor. This is a quote that I took from *Nucleonics Week*, actually was in the article two weeks ago. It was the lead article. Second one was a presentation of IRIS for NRC. Basically they're saying that the pebble bed can meet its challenge on having all these things missing but you can not do that for LWR. The point here is not to compare IRIS with pebble bed. It's comparing the LWR.

What the perception is, with LWR you can not take a loss of coolant, a loss of residual heat removal system, and also measures the core cooling system. That is true until you know IRIS.

In case of IRIS, IRIS can do that because the loss of coolant accident is resolved by the safety of the design. Large LOCAs do not happen, small LOCAs are taken care essentially with no consequence. For the residual heat removal system, we have a three independent diverse system. We have the steam generators, we have the residual heat removal interchangers and we have the containment because the containment is coupled thermodynamically with the vessel so removing the heat from the containment essentially goes on removing for the vessel. And the containment is cooled both by air and water, depending on the size.

In the case of the emergency core cooling, core cooling is not needed. We don't have any CCS. What you really want is, anyhow, the gravity make-up is available. So that shows that really IRIS is a new breed of a light water reactor with a much, much better safety. It's a new dimension. Next, please.

Maintenance is the next thing. In the case of IRIS, since we're refueling every four years or so or five years, eight years, it doesn't make much sense to stop and make maintenance refueling every three months. Economically it doesn't make any sense. Besides, it provides access to third world country proliferation resistance. So what we looked at is to say let's have maintenance shut down synchronized with the refueling which means every four years, every 48 months. Next.

This was work done by our team member from MIT and basically this is the philosophy on the surveillance. "Defer if practical, perform on-line when possible and eliminate by design where necessary." Next one.

Essentially, what we look at is be accessible on-line or do not require any off-line maintenance and the first thing is have high reliability. So this is the beauty of doing the design now from scratch. We're designing all our components to have on-line maintenance or a reliability that exceeds the 48 months. That is built in our design. It's not done after. We're doing that now. Next, please.

In the case of the MIT work, a couple of years ago they looked, actually, it was five years ago. They looked at PWR and BWR to extend it to 48 months and this is 18 month cycle. These are the on-line, off-line. What they did, they say let's go to 48 months. What happens is you're increasing the number of on-line. These are the ones off-line that can be extended beyond the 48 months. And they had 54 they couldn't handle. So 54 could not be handled for regular PWR in either way, either on-line maintenance or extended off-line.

When we look at IRIS, these are regular loop of PWR. Now let's do for IRIS. Fifty four became seven. So we now have seven items of maintenance out of 4,000. We have seven items. If we resolve them, we have maintenance every 48 months. And we are working on that. We have several members of the team are working on that. Next.

This is the one I really wanted to talk because I gave a very brief rundown. I cut out a lot of stuff. I'd be happy to answer all the questions either now or later on. But this is our approach. The first one is important. We do not need a prototype. When people say, when are you going to have the IRIS prototype, I hit the roof. I don't need a prototype. A prototype is for new technology. A prototype of a ship import or the prototype for the leaking matter reactors. IRIS does not break any new technology. it's light water reactor technology, it's only good engineering. All you need is good testing, not a prototype.

So what we have in IRIS is a first-of-a-kind and, again, we believe that around 2010 or soon after we can deploy the first of a kind. Future improvements can be implemented in Nth-of-a-kind. What we have with IRIS is not a static design. A module doesn't cost that much. You're talking a couple of hundred millions or so we're not talking billions. So we can easily put improvements in next modules. For example, the extended core reloads will be in a second or third module. Next.

So you ask, what are licensing challenges and opportunities versus the Gen IV reactors? First of all, the first fuel core is well within state of the art. So we have no challenge whatsoever. It's just a regular PWR. The reloads and higher enrichment fuel and they have to be handled through a licensing extension. We're talking post-2015. So it's not an issue now. That will come later. IRIS does have a containment and this containment, in addition to the classic function, is thermal-hydraulically coupled and chokes off the LOCA. You've seen that.

The safety by design eliminates some accident scenarios like the LOCAs, if we have internal CRDMs and diminish the consequences of others. So here is a chance for significant streamlining. When I say the SSAR, simplified safety analysis, I hope I don't have to go through -- of LOCAs because that's a waste of time. So that's something that we have to discuss. How can we simplify because some things do not happen?

And here is a risk informed regulation. Commissioner Diaz said this morning one thing that it just hit me. He said it was deterministic, experimental and probablistic. But the first word was deterministic. Deterministically, our accidents for LOCAs is zero deterministically. So we are starting with IRIS, we are starting from a very strong basis. So if we take the safety by design basis of IRIS and we put on top the risk informed regulation, I think we have a very, very good safety study which means that with improved safety we can improve the licensing position and we can really have that zero emission or so that we are talking for Generation IV. It was a lofty goal for 2030.

I believe with IRIS that goal is in the next 10 years so when we are able to build one because with this, I think we have a very good chance to go with no evacuation of the staff.

And here is one question. Our maintenance is every 48 months rather than 18 months. There are some regulations that are tied into 18 months. So we say are there regulatory changes necessary to accommodate extended maintenance? That's just a question. I don't think it's a measured thing. And there are things that was already mentioned before with the PMBR. We had modules with common parts like control room and so forth which, of course, have no intention to be the one control room for each module. So we've got to have one room for several modules and so those are things that has to be addressed. Next, please.

The other question you had was what is approach to licensing, construction and operation versus Gen II? First of all for licensing. We do not see at this time any unique major changes. It's simplification, streamlining. We don't see any major changes. There is, however, one thing. The testing to confirm IRIS unique traits. For example, the safety by design and the LOCA is great, is based on first principle. We have three codes independently producing the same results but we want to have testing. We want to have experimentally confirmed data. We do not have to have prototypic testing. That doesn't make any sense.

We can do scale testing and properly scaled testing with the proper parameters and so forth and look at the parameters. That's something that has to be done as soon as possible because that takes time. That's a long lead item.

So the safety of the design, the integral components like the stem generators and some of those have already been tested, maybe some of the tests have to be done for the IRIS conditions. But most of the tests have been already done.

The maintenance optimization, the inspections. Again, we have the components in the core for 48 months or so where inspections are required.

In terms of construction, IRIS is modular. It's modular fabrication. It's modular assembly. So it's a different ball game from the Generation II. You have big items on-site and so forth. Bechtel is one of our team members and Bechtel has the most advanced of the EPC tools and we're going to take advantage of Bechtel EPC for doing our construction. We've already been talking. Bechtel is already planning on putting that to full speed on IRIS.

Here is one thing that's interesting. It is the multiple parallel suppliers. What we have with IRIS, we have several suppliers all over the world. For example, out steam generators can be fabricated by Ansaldo, by Ansel, by MHI. Three different countries.

So what we have here, we have redundancy of suppliers and something that obviously is an advantage. If properly managed, it's definitely an advantage. We have a staggered module construction. Cost-wise, it makes a lot of sense. What we did -- economically for three IRIS modules and three years stagger it. Basically, when we started building the third one, the first one already is producing electricity and has return. So with the module reactor you can do that. It's nothing different. No pebble beds to sit in, any modular design is a logical thing to do. We stagger it.

In terms of operation, we have an extended cycle length with a straight burn and we have the maintenance no sooner than 48 months. That is different, of course, from Gen II. And we have refueling shutdowns. Right now it's five years. Eventually after the reloads we can push up to eight to 10 years.

These things combined means there's a reduced number of plant personnel. We're not going to have 1,000 people at IRIS. No way. You're probably talking one-tenth of that. So it really has quite an effect on O&M costs. And we have a multiple modules operation which again is different from Gen II. And I'm not talking a twin you may think a part of three, five or more IRISes.

Next, please. Now what about the schedule? This was your question. Okay. The two key dates for the 2005 SAR. A little more important is the 2007, 2007 is an ambitious objective.

Now how can we meet that? Several things have to happen. First of all, the lead testing we are to initiate by early next year. The testing takes time. If we don't start at least the planning, the analysis, all of that by early 2002, essentially this date is going to slide to 101 because obviously we can not have signed certification until we have the test results. In testing, you can't accelerate this up to a point. So this is one key thing.