

# UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION

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ADVANCED BWR STANDARD PLANT REVIEW

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NUCLEAR REGULATORY COMMISSION

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BRIEFING BY GENERAL ELECTRIC ON THE  
ADVANCED BWR STANDARD PLANT REVIEW

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PUBLIC MEETING

Nuclear Regulatory Commission  
One White Flint North  
Rockville, Maryland

Wednesday, November 1, 1989

The Commission met in open session, pursuant  
to notice, at 10:00 a.m., Kenneth M. Carr, Chairman,  
presiding.

COMMISSIONERS PRESENT:

KENNETH M. CARR, Chairman of the Commission  
THOMAS M. ROBERTS, Commissioner  
KENNETH C. ROGERS, Commissioner  
JAMES R. CURTISS, Commissioner

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## STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

SAMUEL J. CHILK, Secretary

WILLIAM C. PARLER, General Counsel

DOCTOR BERTRAM WOLFE, Vice President and General  
Manager of GE Nuclear Energy

DOCTOR DANIEL R. WILKINS, ABWR Program General Manager

P.W. MARRIOTT, Manager, Licensing and Consulting  
Services

JOE QUIRK, Program Manager



## P-R-O-C-E-E-D-I-N-G-S

10:04 a.m.

CHAIRMAN CARR: Good morning, ladies and gentlemen.

The purpose of today's meeting is for the General Electric Company to brief the Commission on the progress of the certification program for their advanced boiling water reactor design, the ABWR.

The Commission was last briefed on this subject by GE in January of this year. In addition, more recently, the NRC staff, NUMARC and EPRI have briefed the Commission on advanced reactor designs in the EPRI Requirements Document.

The Commission is considering the priority to be applied to these reviews in light of resource constraints and the apparent lack of express domestic interest in purchasing an evolutionary light water reactor. Factors of concern include concurrent development of specific advanced evolutionary designs and the EPRI Design Requirements Document for evolutionary designs and the indication that current industry activity in progress and planned will not lead to the Commission's goal of standardization.

Today we look forward to hearing another perspective as the Commission considers what

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1 priorities should be given to these reviews.

2 I understand that copies of the slides  
3 presentations to be used today are available at the  
4 entrance to the meeting room.

5 Do any of my fellow Commissioners have any  
6 opening comments?

7 If not, Doctor Wolf, please proceed.

8 I might add, I may have to leave a little  
9 early to go participate in an exercise, and if I do,  
10 why, Commissioner Roberts will take over.

11 DOCTOR WOLF: Thank you, Commissioner Carr.

12 Let me just introduce my colleagues here.  
13 We've got, to my far left, Joe Quirk, who is managing  
14 our certification program. To my left here, Dan  
15 Wilkins, who's in charge of the ABWR program and, to  
16 my right, Pat Marriott, who manages the licensing  
17 activities for General Electric Nuclear.

18 I have a prepared statement and in the  
19 interest of time, Commissioners, I thought I'd read it  
20 rather than extemporaneously take some time to  
21 elaborate on it.

22 We appreciate this chance to meet with the  
23 NRC on the GE ABWR Certification Program. This is our  
24 fifth meeting with the NRC since the program began in  
25 late 1986. We believe the program is progressing well

1 and is still basically on target. Doctor Wilkins, to  
2 my left, will give you a status report shortly.

3 But first, I would like to address several  
4 questions that have been the subject of recent  
5 discussions among the NRC, the NRC staff, staff and  
6 groups representing the industry.

7 First, I'd like to address the question of  
8 whether there's a U.S. market for the evolutionary  
9 light water reactor. My answer is I think there is.  
10 I can tell you that the U.S. utilities, the government  
11 and industry are making major investments in the  
12 evolutionary LWR as the best way to provide our  
13 country with a nuclear option when new base load  
14 commitments are needed. Utilities will need to commit  
15 new base load plants in the 1990s.

16 (Slide) The first chart, I think, is a very  
17 important chart, if you would put that on, please.

18 What the chart shows is that since the Arab  
19 oil embargo of 1973, when load growth in the United  
20 States was cut roughly in half, electrical load growth  
21 was cut roughly in half, we've had a surplus of  
22 capacity here in the United States. We've gone from  
23 the roughly minimum requirements of some 16 to 17  
24 percent prior to the '73 Arab oil boycott to excess  
25 capacities approaching 30 percent.

1           In this period one could, without  
2 significant consequences, be against new coal plants,  
3 nuclear plants, dams, oil exploration and even  
4 geothermal power when it was near active fumaroles or  
5 mud pots. Indeed, some organizations took exactly  
6 this position. This excess capacity led to the  
7 succession of new nuclear plant commitments and, in  
8 fact, cancellation of many nuclear as well as fossil  
9 units.

10           However, the situation is ending.  
11 Electrical brownouts occurred in the Eastern U.S.  
12 during the past two summers and new base load  
13 commitments will be needed in the early '90s to avoid  
14 electrical shortages on a national scale. Estimates  
15 for the new generating capacity needed by the end of  
16 the century range from 100 to 200 gigawatts electric.

17           There are no perfect energy sources.  
18 Environmental issues including air pollution, the  
19 greenhouse effect, acid rain and oil spills are  
20 receiving front page attention and the public is  
21 becoming increasingly aware of the risks of burning  
22 fossil fuels. In addition, there is increasing  
23 concern over our rising dependence on imported oil  
24 which now constitutes 40 percent of our oil supply and  
25 subjects us to the vagaries of Mid East governments.

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1           The coming need for power and the rising  
2 importance of environmental and energy security issues  
3 are creating a renewed interest in the revival of  
4 nuclear power. This is why U.S utilities, government  
5 and industry are investing in the ALWR, in the near-  
6 term the evolutionary ALWR, to ensure that the option  
7 is available when difficult choices must be made.

8           In GE's case, our ABWR has several hundred  
9 million dollars invested in its design and development  
10 by GE and its worldwide associates. It's been adopted  
11 as the next generation standard BWR in Japan and a two  
12 unit lead project has been committed by the Tokyo  
13 Electric Power Company.

14           We are seeking NRC certification of the ABWR  
15 design because we believe it could be an excellent  
16 plant for U.S. application, not just to support our  
17 overseas business. With the serious energy problems  
18 facing the U.S., we believe it important that the  
19 American public not have excluded from them meaningful  
20 options which could ameliorate the problems.

21           Perhaps the most important factor governing  
22 whether utilities will be able to turn to nuclear to  
23 fill their future needs will be the existence of NRC  
24 certified standard designs. Lead time for design,  
25 developments and certification is on the order of five

1 years or longer and it is unlikely that any utility  
2 will order a nuclear unit unless it's certified in  
3 advance. This necessitates that we conduct the design  
4 and certification work now as a precondition to any  
5 market need.

6 Further, and importantly, the ABWR  
7 certification proceeding provides both the occasion  
8 and the opportunity for a working demonstration of the  
9 effectiveness, predictability and timeliness of a  
10 major element of the Commission's Part 52  
11 standardization and licensing regulations. This also  
12 is a vital factor governing whether utilities will  
13 turn to nuclear, will be able to turn to nuclear as a  
14 viable option to fill their future energy needs.

15 Let me turn to some generic questions on  
16 safety issues.

17 The second question I would address is  
18 whether the ALWR issues should be resolved  
19 generically. We believe the answer is yes to the  
20 extent practical. We should be careful, however, not  
21 to impose generic solutions of ALWR issues where  
22 plant-specific resolutions would achieve better  
23 results. Our experience has been that generic  
24 resolution of advanced light water reactor issues  
25 frequently results in least common denominator

1 approaches that fail to exploit plant-specific  
2 opportunities which only become apparent in the  
3 context of a specific design. Certification itself  
4 represents a generic resolution of issues for a class  
5 of standard plants and has the advantage that issues  
6 can be considered within the context of an actual  
7 design rather than in a more abstract context.

8 We believe the EPRI advanced light water  
9 reactor requirements and the DOE ALWR Certification  
10 Programs provide an unusually effective vehicle for  
11 considering both the generic and the plant-specific  
12 aspect of issues. We encourage the NRC to continue to  
13 support these programs. We recommend against generic  
14 rulemaking as an approach to the resolution of the  
15 ALWR issues at this time. Generic rulemaking would be  
16 an enormously disruptive event of both the ALWR  
17 Requirements Program and the ALWR Certification  
18 Programs which have had major private sector  
19 investment and are nearing completion.

20 GE has been a participant in the EPRI ALWR  
21 Requirements Program since its inception. The ABWR  
22 currently under review by the NRC staff is in  
23 substantial conformance with the utility ALWR  
24 requirements.

25 In a few areas, most notably hydrogen

1 control and containment overpressure protection, we  
2 have elected to exceed the EPRI requirements. In the  
3 case of hydrogen control, this was done to avoid a  
4 lengthy discussion of an issue which has no real  
5 consequences for the ABWR. In the case of containment  
6 overpressure protection, it was done to take advantage  
7 of unique ABWR features to provide a substantial added  
8 measure of off-site public and property protection  
9 which could be exceeded at a very modest cost.

10 In these two areas, we fully support the  
11 generic positions reflected in the ALWR Requirements  
12 Documents while, at the same time, believe there are  
13 sound reasons for the ABWR to exceed these  
14 requirements on a certified standard plant basis.  
15 Doctor Wilkins will discuss both of these areas in  
16 more detail in his presentation.

17 We appreciate the very strong support the  
18 NRC and the NRC staff have provided to the ABWR  
19 Certification Program which was initiated in 1986. We  
20 believe the program has been remarkably successful to  
21 date and is on track to provide a convincing  
22 demonstration of the benefits of Part 52 standard  
23 plant licensing process. It is being closely followed  
24 in the United States and around the world as a  
25 pioneering effort which will set the direction for

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1 plant standardization in the second nuclear age. We  
2 request your continued support and I assure you that  
3 GE is fully committed to the successful completion of  
4 the program.

5 Thank you very much.

6 I'd be pleased to answer questions on that  
7 statement.

8 CHAIRMAN CARR: Any questions?

9 Well, wait. You can go ahead and proceed  
10 with the rest of the brief.

11 MR. WOLFE: I'd like to turn it over to Dan  
12 Wilkins then who will give you a more detailed update  
13 on the progress of the certification program.

14 DOCTOR WILKINS: (Slide) Could I have the  
15 next slide, please?

16 I will begin with just a brief reminder of  
17 what the ABWR is and where we are in the program. The  
18 ABWR is a 1350 megawatt reactor designed by an  
19 international team of BWR manufacturers by pulling  
20 together into a single design the best proven features  
21 from BWRs around the world. So, it is both an  
22 advanced and a proven design.

23 The development effort is complete, amounted  
24 to some \$250 million in development work plus on the  
25 order of another \$100 million at this point in design

1 effort.

2 (Slide) Next slide, please.

3 In the U.S., the certification program is  
4 well underway, aimed at making -- having the ABWR  
5 certified as the first U.S. standard plant. This is a  
6 cooperative effort between the U.S. Department of  
7 Energy, the Electric Power Research Institute and  
8 General Electric, and it has a two-fold purpose.  
9 First, to provide an evolutionary LWR option for the  
10 U.S. in the early '90s and, second, to demonstrate the  
11 standard plant licensing process.

12 The effort, as I mentioned, began in 1986  
13 and is scheduled to be complete in 1991. So we're  
14 about 70 or 75 percent into the mission at this point.

15 (Slide) Next chart, please.

16 In Japan, the ABWR has been adopted as the  
17 next generation standard boiling water reactor for  
18 Japan. The lead plants are committed by the Tokyo  
19 Electric Power Company, two units at their Kashiwazaki  
20 site. They are currently in licensing on essentially  
21 the same schedule as here in the U.S. and the  
22 construction will begin in '91 with the first unit  
23 achieving commercial operation in '96 and the second  
24 one in 1998. I might say that the activity in Japan  
25 is also very much on schedule at this point.

1                   (Slide)    The two units in Japan -- next  
2 chart, please -- will be provided by a joint venture  
3 of General Electric, Hitachi and Toshiba. Within the  
4 joint venture, General Electric is responsible to  
5 supply the nuclear steam supply systems, the fuel, the  
6 turbines and the generators for both units. Because  
7 of the parallel licensing schedule in Japan and the  
8 U.S., there is a great deal of regulatory interaction  
9 between the two countries. You might say that this is  
10 really on the track at the present time to becoming an  
11 international standard plant.

12                   (Slide)    May I have the next chart?

13                   The schedule for our U.S. certification is  
14 shown here. This is the same schedule that we have  
15 used in prior meetings. In fact, it is the schedule  
16 contained in the licensing review basis which was  
17 issued by the staff in 1987 and we are both, GE and  
18 the staff, are continuing to measure ourselves against  
19 that original schedule. It provided for modular  
20 submittals of the safety analysis report. That was  
21 done to enable the program to be in proper schedule  
22 relationship with the EPRI Requirements Document  
23 submittals. If you look at the fourth quarter of '89  
24 there, you can see that at this point the safety  
25 analysis report submittals are supposed to all be in

1 to the NRC and they essentially are. The NRC staff  
2 review is in full swing at this point and I'll talk a  
3 little more about that with safety evaluation reports,  
4 either drafted or being drafted.

5 Looking forward, the schedule calls for the  
6 final design approval in September of '90, followed by  
7 the certification a year later in '91.

8 (Slide) The scope -- next chart, please--  
9 on the ABWR was expanded early in the program at some  
10 urging from the NRC. We had originally envisioned  
11 only the nuclear island portion of the plant as the  
12 scope of certification, but have since expanded it to  
13 include the essentially complete plant. All of the  
14 buildings in the crosshatched area in the figure are  
15 within the scope that is being reviewed under the  
16 certification program.

17 (Slide) Next chart.

18 The program has three tasks which are  
19 described on the chart. I'd like to highlight just  
20 the first one. The licensing review basis was  
21 completed in 1987. This developed, in effect, the  
22 blueprint for the certification process, for the  
23 review and certification process, by establishing  
24 review procedures and interfaces. The review schedule  
25 and acceptance criteria on some of the technical

1 issues.

2 And I might say that from our perspective  
3 this has been very successful. We are still  
4 proceeding right down the course that the licensing  
5 review basis laid out more than two years ago and we  
6 found that it's been an extremely helpful document in  
7 terms of guiding the process.

8 (Slide) Next chart, please.

9 We have had a very active review and  
10 dialogue with all of the parties involved in the  
11 review and certification effort on the ABWR and I just  
12 listed there the various meetings we have had with the  
13 Commission, with the ACRS Subcommittee and full ACRS,  
14 and with NRC staff management. So you can see that  
15 there's a great active dialogue going on.

16 (Slide) Next chart, please.

17 The standard safety analysis report status  
18 is shown on this chart. We now have all chapters of  
19 the standard safety analysis report into the NRC staff  
20 for review. I say 98 percent complete instead of 100  
21 because there are a few loose ends that we have yet to  
22 submit to get up to 100 percent. But the full  
23 description of the design, with few exceptions, is now  
24 before the NRC staff.

25 (Slide) Next chart, please.

1           The requests for additional information,  
2 numerous requests, have been received from the NRC  
3 staff. To date we've received some 598 questions on  
4 the ABWR submittals and have provided responses to  
5 some 524 of them. So you can see that there's a very  
6 active review effort going on and active effort on our  
7 part in terms of responding to that review.

8           CHAIRMAN CARR:     How many of those are  
9 satisfactorily resolved?

10          DOCTOR WILKINS:   From our perspective, we do  
11 not see any major unresolved issues at this point. I  
12 think you would have to put that same question to the  
13 NRC staff, but we think the review is going very well.

14          Now, I'd like to devote most of the  
15 remainder of my discussion to what I think is perhaps  
16 the most important technical areas in the review and  
17 that's the severe accident capability of the ABWR.

18          We submitted in January a probabilistic risk  
19 assessment for the ABWR which covered internal events  
20 and this past summer we submitted the second portion  
21 of it which covered external events. So, we now have  
22 the probabilistic risk assessment work completed. It  
23 covers both prevention and mitigation of accidents and  
24 it addresses both the probability of core damage and  
25 the off-site consequences of accidents.

1 I'd like to give you an overview of the  
2 results and some of the thinking that went into the  
3 decisions we made in the course of that. This design,  
4 I might say, is one that has benefited from the PRA in  
5 that after we did the PRA we changed the design and  
6 added some features which weren't there earlier. I  
7 want to particularly talk about those.

8 (Slide) On this chart and the next two, I  
9 have summarized some of the key features of the ABWR  
10 which contribute to its very good accident prevention  
11 capability, which we've designated with a P, and its  
12 mitigation features, which we've designated with an M.  
13 I won't go through all of them, but I would like to  
14 highlight a few.

15 The stability issue is handled in the ABWR  
16 by having an automatic run-in of rods. If you  
17 approach the region of operation, you would have  
18 marginal stability. So, you're precluded, in effect,  
19 from operating in that region.

20 The pressure vessel provides no large  
21 nozzles below the core. Because of the internal  
22 recirculation pumps, we have a large water gap around  
23 the core which provides very low fluence to the  
24 vessel.

25 We have integrated the containment and

1 reactor building to provide a very high seismic  
2 capability. In fact, the design is being analyzed for  
3 0.3 G on any site within the envelope. So, for any  
4 specific site, in fact, it would be somewhat higher  
5 than 0.3.

6 We've applied everything we know about BWR  
7 materials and water chemistry problems. All of the  
8 materials being used have been qualified either  
9 through testing or in field service and in most cases  
10 both. We've adopted a belt and suspenders approach in  
11 the sense that we are, in addition, planning to apply  
12 hydrogen water chemistry to the ABWR.

13 (Slide) Next chart, please.

14 In the system design area, the plant is  
15 designed for no fuel uncovering during any loss-of-  
16 coolant accident, including any break of any line  
17 without uncovering the core. We have three full  
18 safety divisions for both core and containment cooling  
19 with, in the case of core cooling, diversity in that  
20 some of those divisions are powered electrically and  
21 others by steam-driven pumps.

22 The control rods, unlike past BWRs, are  
23 diverse. They can be inserted both electrically and  
24 hydraulically and we've eliminated the scram discharge  
25 volume, which was a source of -- is a potential source



1 of common mode failures.

2 The containment is inert for hydrogen  
3 control. We've gone to advanced solid state fault  
4 tolerant safety systems in the control and  
5 instrumentation area with full two out of four safety  
6 system logic.

7 (Slide) Next chart, please.

8 Finally, and I'll talk about these each in a  
9 little more detail, we have added some severe accident  
10 features which really go beyond what we have done on  
11 previous BWRs. We're conscious of the NRC policy that  
12 future plants should be a step forward in safety.  
13 Three out of these four features are, in fact,  
14 required by the EPRI ALWR requirements and our  
15 decision to put them on was made in close cooperation  
16 with EPRI. I'll talk a little more about them.

17 (Slide) But before I do that, in the next  
18 chart I've summarized the results of our probabilistic  
19 risk assessment against the goals we've set.

20 In terms of core damage frequency, the EPRI  
21 ALWR requirements and our licensing review basis in  
22 1987 set a goal of  $10^{-5}$  per year or less. Our ABWR  
23 results indicate  $4 \times 10^{-7}$ . So we have exceeded the goal  
24 we set by a factor of about 25 in terms of probability  
25 to have core damage.

1           The licensing review basis also established  
2           a containment performance goal. The goal we selected  
3           was a conditional containment failure probability and  
4           we set the goal at 0.1. The ABWR PRA work indicates  
5           that we have a conditional containment failure  
6           probability of 0.004. So, again, it's about a factor  
7           of 25 times beyond the goal that we set.

8           Finally, both the ALWR requirements and the  
9           licensing review basis set an off-site risk goal of  
10          less than 25 rem off-site. Off-site was defined as  
11          half a mile at the  $10^{-6}$  probability level. In the  
12          case of the ABWR, the core damage frequency is, in  
13          fact, below  $10^{-6}$ . So, we, in effect, have zero off-  
14          site risk at that probability level. And I'll show  
15          you shortly what it looks like at other levels.

16          COMMISSIONER CURTISS: Before you leave that  
17          chart, I wonder if you could say a few brief words  
18          about what the logic is in your mind of having a  
19          conditional containment failure criteria? Why is that  
20          something that you think makes sense to do?

21          DOCTOR WILKINS: Well, we think there are--  
22          we think it makes sense to have a measure of  
23          containment performance. We think that the  
24          conditional containment failure probability is one  
25          logical way to approach that problem. I don't think

1 we would say it's the only one. There may be others,  
2 but it's one that the more we've looked at, the more  
3 logical it looks. And I might say that if you didn't  
4 set that as a containment performance criteria, then  
5 you have to consider the question of how would you  
6 feel if you set some other one and the conditional  
7 containment failure probability is high. We think  
8 this is a logical way to do it, certainly not the only  
9 one.

10 COMMISSIONER CURTISS: Has it had any impact  
11 on the approach that you're taking on the prevention  
12 side?

13 DOCTOR WILKINS: No.

14 COMMISSIONER CURTISS: By knowing that you  
15 have to meet a conditional containment failure  
16 criterion, does it affect the logic on prevention  
17 rather than mitigation or the balance between the two?

18 DOCTOR WILKINS: Not really because to have  
19 a properly optimized system, your containment should  
20 handle what your PRA tells you are dominant sequences.  
21 In that context, if you do something to make those  
22 sequences better, both the core damage probability and  
23 the off-site risk go down and the containment failure  
24 probability tends to stay the same. So, it has not  
25 had any adverse effect in terms of our approach to it.

1           Let me talk about these four features that  
2 we have added to deal with the severe accident issue.  
3 Again, I'll try to do it very briefly.

4           (Slide) Can I have the next chart, please?

5           The first one is the addition of a gas  
6 turbine to provide an alternate source of on-site AC  
7 power. This was required by the EPRI ALWR  
8 requirements. It provides diversity in terms of on-  
9 site AC power. We now have both diesel capability and  
10 gas turbine capability and it therefore reduces the  
11 frequency of station blackout.

12           The diagram shows how we have hooked this  
13 in. In effect, the gas turbine can backup any of the  
14 three safety divisions or the operational buses that  
15 handle the plant investment protection loads. So,  
16 it's a whole other layer of reliability that goes  
17 beyond what we have had on existing plants.

18           (Slide) The second one, and this again is  
19 one that are our PRA shows us is quite attractive, is  
20 we have taken advantage of a unique BWR capability,  
21 namely the ability to depressurize the reactor to  
22 provide AC independent water addition. This is done  
23 by providing the piping and valves which would enable  
24 you in a very unusual situation to add fire water to  
25 either cool the reactor or to flood the containment.

1 This can be done either from the standpipe or, if  
2 necessary, could actually be done from a fire truck.  
3 This is made possible in the BWR because we have the  
4 provisions there to depressurize the reactor and to  
5 handle safety at ambient conditions.

6 So, these features which are relatively  
7 modest in cost and easy to add, provide another layer  
8 of protection for the reactor and the containment.  
9 They would be operated manually. In fact, the valves  
10 you have to operate to perform this water addition are  
11 all in one room and would be relatively easy to carry  
12 out. This does not provide the passive safety that we  
13 are looking at in the longer term for plants beyond  
14 the ABWR, but this is very close to providing a  
15 passive capability even in the evolutionary generation  
16 of plants.

17 I will, in the interest of time, skip over  
18 the next two charts which talk a little more in detail  
19 about the water addition. Let's go to the one that  
20 says lower drywell flooders.

21 (Slide) This is again a feature that was  
22 called for in the EPRI ALWR Requirements Document.  
23 The ABWR has a large cavity below the vessel which is  
24 there to provide maintenance space and equipment for  
25 the control rod drives and the pumps. But that cavity

1 also provides an opportunity to ensure that if there  
2 were a core damage accident in which the core came  
3 through the bottom of the vessel, that it would be  
4 handled in an effective way.

5 What we have done is provided a fusible plug  
6 that would allow, if the under vessel region became  
7 very hot due to the presence of corium, would flood it  
8 and allow the suppression pool water to enter that  
9 region. This provides for an early and very reliable  
10 passive water addition to the under vessel region,  
11 would quench any corium that arrived there and stop  
12 the core concrete reaction and also greatly reduce the  
13 temperatures within the containment. Again, it's a  
14 feature. The only thing really we're adding is that  
15 fusible plug and it provides another layer of  
16 protection beyond existing plants.

17 DOCTOR WOLFE: It, in effect, allows you to  
18 make an assumption that you've just got a core on the  
19 floor and the design takes care of it without arguing,  
20 as we would normally argue, that that probability is  
21 very, very small.

22 DOCTOR WILKINS: (Slide) Let me speak to  
23 the hydrogen generation issue, which I know has been a  
24 topic of discussion between the NRC and the staff and  
25 the industry on future plants. I'll try to give you

1 our perspective on it.

2 The current NRC regulations require that we  
3 design for 100 percent metal water reaction. EPRI, in  
4 its requirements document, has submitted a technical  
5 case to the staff that supports 75 percent as being  
6 conservative. GE was involved in the EPRI work. We  
7 believe that 75 percent is, in fact, conservative and  
8 support EPRI in that view. On the other hand, it's  
9 inconsequential for the ABWR.

10 (Slide) Look at the next chart.

11 It turns out in the ABWR that the size and  
12 pressure capability of the containment is set by other  
13 considerations and nothing would be different if we  
14 adopted 75 percent instead of 100 percent. So, we  
15 opted to do our analyses at the 100 percent level and  
16 we can obviously meet 75 percent if that's the  
17 outcome, but it won't make any difference on the  
18 design whichever way it is. So, we chose not to  
19 engage in lengthy discussion of an issue that really  
20 had no consequence for us. That's why we have taken  
21 the course we have.

22 (Slide) Let me talk about containment  
23 overpressure protection on the next chart. This is  
24 the final severe accident measure I want to talk  
25 about. This one is not required by the EPRI ALWR

1 requirements. What we are doing with the ABWR goes  
2 beyond those requirements and I'd like to give you our  
3 perspective on this. And this one, I might say, is a  
4 continuing area of discussion between ourselves and  
5 the staff.

6 In any PRA for a light water reactor, there  
7 are some sequences that if you carry them to a  
8 sufficiently degraded state they lead to containment  
9 failure. In the BWR, when we do those analyses, the  
10 location of the failure is very important. If the  
11 failure occurs in the drywell, you have an unfiltered  
12 release. If it occurs in the wetwell below the water  
13 level, you lose the water. And if it occurs in the  
14 wetwell above the water level, you have a filtered  
15 release that has -- any fission products that would be  
16 released would be scrubbed.

17 Because of that, we felt that in the ABWR it  
18 would be appropriate to make sure that we controlled  
19 the location of the failure for these extremely  
20 unlikely events. The way we do that is by putting a  
21 rupture disk in the wetwell air space with two  
22 downstream valves which are normally open. That is  
23 then piped to the stack. The rupture disk would be  
24 set slightly below the ultimate capability of the  
25 containment. So, because of that, we characterize



1 this as overpressure protection as opposed to a vent.  
2 It is there to ensure that if containment failure is  
3 inevitable, that you get a benign failure.

4 (Slide) On the next chart we discuss some  
5 of the benefits. It's a passive system. Our PRA  
6 indicates that it would be very unlikely to ever be  
7 used down in the  $10^{-7}$  per year range. By the way  
8 we've designed it, we think there is very little risk  
9 of it being misused. The operator can't open it.  
10 It's a rupture disk and only mother nature can open  
11 it.

12 It has the advantage of making -- if the  
13 failure is going to occur anyway, it makes it benign.  
14 What I mean by that is the release is scrubbed by the  
15 suppression pool. It's an elevated release. The  
16 operator can later reclose it and because of this it,  
17 in effect, makes the containment a fail safe  
18 containment. It virtually eliminates off-site doses  
19 greater than 25 rem for any of the accident sequences  
20 we've studied. It has the advantage of making sure we  
21 don't lose the core cooling water in the process. It  
22 has very high seismic capability and it's a passive  
23 feature.

24 (Slide) If you look on the next chart, we  
25 show the impact it has on our probabilistic risk

1 assessment. The upper curve shows the probability of  
2 exceeding certain off-site doses without the  
3 containment overpressure protection feature. The  
4 lower curve shows the probability with it and you can  
5 see that it's worth about a decade in terms of  
6 reducing off-site risk. Plus, it virtually eliminates  
7 the possibility of large off-site releases greater  
8 than 25 rem.

9 So, our thinking has been that this is a  
10 worthwhile insurance policy. It's something that can  
11 be done at very modest cost in the ABWR because it  
12 takes advantage of features and capability which are  
13 already there. Because of that, we've elected to  
14 exceed the ALWR requirements in this area.

15 COMMISSIONER CURTISS: Let me ask a question  
16 on this chart. If I read it correctly, it looks to me  
17 like you -- just roughly you would meet the EPRI  
18 Requirements Document goal as well as the safety goal  
19 of the Commission, according to your PRA, at about  $10^{-7}$ .  
20 Do I read that correctly?  $10^{-6}$ ?

21 DOCTOR WILKINS: The box up in the corner is  
22 the goal represented by the ALWR requirements.

23 CHAIRMAN CARR: Both of these meet those  
24 requirements.

25 COMMISSIONER CURTISS: Yes.

1 DOCTOR WILKINS: Yes, both of them.

2 COMMISSIONER CURTISS: In view of that, I  
3 take it what that means is that without the vent,  
4 without the overpressure feature, according to your  
5 PRA, you would fully satisfy the EPRI goal as well as  
6 the NRC safety goal.

7 DOCTOR WOLFE: That's correct.

8 COMMISSIONER CURTISS: Is that correct?

9 DOCTOR WILKINS: Correct.

10 COMMISSIONER CURTISS: Why isn't this an  
11 issue that really is in the background noise then in  
12 terms of overall risk? Why is it that you think this  
13 feature is necessary if, according to your PRA, you  
14 meet both the safety goal of the Commission as well as  
15 the requirements document?

16 DOCTOR WILKINS: Well, I don't think we  
17 would say it's a feature that's necessary. We think  
18 it's a feature that for a very modest cost provides a  
19 substantial degree of protection.

20 DOCTOR WOLFE: But let me put it a different  
21 way, Jim. It provides a satisfaction, I think, that  
22 goes beyond detailed calculations. In other words, as  
23 designed this way, you can ask a question, what if the  
24 core goes on the floor and all your safety devices  
25 fail? The answer is, in this case you can let the

1 core go on the floor and through this vent you  
2 essentially get no significant off-site dose.

3 Now, if you go through the analysis to your  
4 point, the answer is you don't need it. It's an added  
5 suspender, belt and suspenders. In our case, this is  
6 something like \$200,000.00, \$250,000.00 extra to a  
7 billion and a half dollar machine, billion dollar  
8 machine. And in our view, just the inherent  
9 satisfaction or inherent ability to make the statement  
10 I just made to you, we think from a public standpoint  
11 and from just the standpoint of saying maybe the  
12 probablistic assessment missed something, is  
13 worthwhile. If it were a billion dollar adder, we  
14 would be here arguing with you that it wasn't  
15 necessary.

16 COMMISSIONER CURTISS: Okay.

17 DOCTOR WILKINS: Let me finish with one  
18 final perspective on the ABWR severe accident  
19 mitigation. The industry is looking longer range at  
20 passive light water reactors, passive safety features.  
21 The ABWR, in fact from the point of view of the  
22 public, has passive protection. The threats to  
23 containment that you worry about in a light water  
24 reactor are failure due to hydrogen, combustion due to  
25 core debris or due to overpressure protection. Those

1 are the basic three ways to fail containment. In  
2 fact, for each of those, the ABWR provides a passive  
3 capability to protect the public against those  
4 threats.

5 So, we have, in a sense, achieved with the  
6 ABRW that is now being reviewed by the staff, many of  
7 the objectives that we are looking at in the longer  
8 range for passive water reactors, including in GE's  
9 case our SBWR, our smaller, simplified BWR.

10 (Slide) In summary -- the final chart -- we  
11 are nearing the three-quarter point on the  
12 certification effort. The program is still  
13 essentially on track. We think the program is on  
14 course to achieve a final design approval next year  
15 and beyond that a certification in '91. We've  
16 completed our severe accident work and meet all of the  
17 goals that we, the EPRI and the NRC have set. We have  
18 a number of remaining actions which we are carrying  
19 out, but we think the program is going along very well  
20 and we're still on the course we set back at the  
21 beginning in 1986.

22 With that, we'll -- questions?

23 CHAIRMAN CARR: Commissioner Roberts?

24 COMMISSIONER ROBERTS: Well, it's  
25 encouraging to hear that a multi-year project that

1 involves the government and the private sector is on  
2 schedule.

3 I've got just a couple of nits. I'm  
4 interested in the Japanese endeavor. If you're doing  
5 the nuclear steam supply of fuel and turbine  
6 generators, what are Hitachi and Toshiba doing?

7 DOCTOR WILKINS: In the first unit, Toshiba  
8 has the balance of the nuclear side of the plant and  
9 Hitachi is handling the balance of the turbine side.  
10 In the second unit, they will reverse roles whereas  
11 our role remains the same. So that by the time the  
12 two units are complete, both of the Japanese suppliers  
13 will have had experience in the entire plant.

14 COMMISSIONER ROBERTS: Where will the  
15 reactor pressure vessel be fabricated and by whom?

16 DOCTOR WILKINS: We will purchase the  
17 pressure vessel in Japan.

18 COMMISSIONER ROBERTS: In Japan? Who will  
19 make it?

20 DOCTOR WILKINS: It will be made by Toshiba  
21 on the first unit and Hitachi on the second.

22 COMMISSIONER ROBERTS: This has nothing to do  
23 with any of the NRC role, but I'm just curious. Have  
24 you publicly announced a projected installed cost per  
25 kilowatt for the Japanese plants? Don't give me an

1 answer if you haven't.

2 DOCTOR WOLFE: We have a number with the  
3 Japanese. I don't know that it's been published and  
4 we'd prefer to not mention it.

5 COMMISSIONER ROBERTS: I understand.

6 CHAIRMAN CARR: You don't want to publish it  
7 here?

8 DOCTOR WOLFE: Pardon me?

9 CHAIRMAN CARR: You don't want to publish it  
10 here.

11 DOCTOR WOLFE: We don't want to publish it  
12 here.

13 COMMISSIONER ROBERTS: Sure.

14 DOCTOR WOLFE: Let me make this comment  
15 though. When we do our analysis of the ABWR for U.S.  
16 application, we think it's going to be a very cost  
17 effective competitive source of power.

18 DOCTOR WILKINS: We have published numbers  
19 in the U.S. overnight cost excluding financing and so  
20 forth, in the vicinity of \$1,100.00 a kilowatt.  
21 That's assuming that it's done on a rapid construction  
22 schedule that you can do with pre-certification and a  
23 pre-approved site.

24 COMMISSIONER ROBERTS: Last question. Slide  
25 17, on you gas turbine alternative AC source. Is this

1 shown for one reactor? Have you got three diesel  
2 generators for each reactor plus the gas turbine?

3 DOCTOR WILKINS: Yes.

4 COMMISSIONER ROBERTS: That's all I have.

5 CHAIRMAN CARR: Commissioner Rogers?

6 COMMISSIONER ROGERS: Yes. I wonder if you  
7 could say a little bit about the assumptions in the  
8 modeling that you did in working out your PRA for the  
9 conditional containment probability? What's the  
10 status of that? What --

11 DOCTOR WILKINS: Well, let me --

12 COMMISSIONER ROGERS: Were there any outside  
13 organizations involved in that as well as your own  
14 internal assessment?

15 DOCTOR WILKINS: Well, we did our own PRA,  
16 but we have been involved with outside organizations  
17 in the PRA area for many years. I think the key  
18 assumptions in that area are we looked at two  
19 different definitions of containment failure. Our  
20 initial definition and one which we see a lot of merit  
21 to was a functional definition where we defined  
22 containment failure as 25 rem off-site. And anything  
23 that produced that obviously must have had a  
24 containment failure.

25 In discussions with the NRC staff, they



1 asked us to look at a different definition of  
2 containment failure, namely any uncontrolled loss of  
3 the pressure retaining capability of the containment  
4 barrier. So, we did the analysis both ways. For  
5 internal events, we are able to meet the 0.1  
6 conditional containment failure probability goal  
7 either way. For external events, we would require the  
8 overpressure protection feature to meet it.

9 COMMISSIONER ROGERS: Well, there have been  
10 a number of questions about the details of a core melt  
11 and its effect on the containment and rupture of  
12 pressure vessel and so on and so forth. I'm just  
13 trying to understand to what extent your PRA analysis  
14 built in certain assumptions about what those models  
15 are and to what extent there's a disagreement in the  
16 community as to the model that you used.

17 MR. QUIRK: Let me say that the PRA analysis  
18 that GE did did look at the phenomenological effects  
19 of what occurs should the molten core penetrate the  
20 vessel and drop in the cavity underneath the vessel  
21 without cooling water. In our original PRA submittal,  
22 we evaluated the structural effect of that. Then we  
23 looked at if there were water down there, what the  
24 phenomenological effect in the generation of non-  
25 condensibles would be arrested and the overall

1 temperature would be suppressed.

2 So, if you're looking for modeling and to  
3 what extent we go in and look at those interactions, I  
4 can assure you we do that. I'm not sure though -- it  
5 seems like you're saying, is this modeling a point of  
6 departure with our associates.

7 COMMISSIONER ROGERS: Yes. There's a common  
8 agreement in the community as to the model that you  
9 used to arrive at those numbers.

10 MR. QUIRK: No, I wouldn't characterize it  
11 that way. But it's not a point of argument either. I  
12 mean each organization has their approach and they  
13 must defend that and calibrate it against other  
14 models, and that's the approach we took.

15 COMMISSIONER ROGERS: Yes, but are the  
16 consequences of these different models significantly  
17 different?

18 MR. QUIRK: We haven't seen another analysis  
19 at the same level of depth as ours has to compare it.

20 MR. MARRIOTT: I think the answer to that is  
21 when the results of the analyses are applied in a  
22 bounding way as they are in the core melt sequences,  
23 in our PRA it doesn't/a great deal of difference what  
24 detailed phenomenological assumptions are used in the  
25 model. As you correctly point out, there's a good

1 deal of, for want of a better word, controversy over  
2 the details of core melt among the national labs and  
3 with NRC Research. But those are phenomenological  
4 niceties which are necessary to model in the severe  
5 core melt sequences in a PRA.

6 COMMISSIONER ROGERS: To what extent have  
7 you had independent organizations look at your PRA  
8 analysis? Is this strictly an internal analysis or  
9 have you had any independent groups look at that and  
10 do it themselves?

11 DOCTOR WILKINS: Well, we did our own PRA  
12 work on our BWR 6 GSAR submittal and that, of course,  
13 was subjected to a review by the NRC staff and also  
14 the NRC staff consultants. And so, many of the  
15 methods that we have used come from our earlier work  
16 on the BWR 6. This PRA, of course, will also be  
17 reviewed by the NRC staff and consultants.

18 MR. QUIRK: We have just recently made this  
19 PRA available to EPRI and their technical associates.  
20 They have that now for their use and study.

21 COMMISSIONER ROGERS: But no comments back  
22 from them on it?

23 MR. QUIRK: They just received it.

24 COMMISSIONER ROGERS: In the area of the  
25 tests, inspections analyses and the acceptance

1 criteria requirement to Part 52, what have you done so  
2 far on that?

3 MR. QUIRK: Well, we have worked with the  
4 NUMARC organization in follow-on to the Part 52 work.  
5 They have set up a NUMARC task force to say the proof  
6 of the pudding in Part 52, in one-step licensing, is  
7 demonstrating that the as-built plant conforms to its  
8 licensed basis. The proof of that pudding is test,  
9 inspections and analysis. Very, very important. So,  
10 NUMARC has taken this upon themselves to draft the  
11 approach and we've been working quite closely with  
12 them in that regard, as other vendors have as well.

13 COMMISSIONER ROGERS: Okay. Thank you.

14 CHAIRMAN CARR: Jim, is it okay if I ask a  
15 couple?

16 COMMISSIONER CURTISS: Fire away.

17 CHAIRMAN CARR: Are you going to request  
18 certification for the exact design you're building in  
19 Japan?

20 DOCTOR WILKINS: Almost.

21 CHAIRMAN CARR: Now you know what my next  
22 question is.

23 DOCTOR WILKINS: We have committed to keep a  
24 list of the differences and to make both the NRC staff  
25 and the Japanese aware of them. That list is

1 continuously maintained.

2 CHAIRMAN CARR: Is it this kind of a list or  
3 is it this kind of a list?

4 DOCTOR WILKINS: I would -- how long a list  
5 is it?

6 MR. QUIRK: It's less than 20, I'd say, some  
7 of them quite minor. You know, we keep track of all  
8 of them. I think we've pointed out some of these to  
9 you. For example, the orientation of the turbine.  
10 Land space being as vital as in Japan, they do not  
11 have an in-line plant arrangement. They turn the  
12 turbine building so that it's perpendicular to the  
13 containment to save space and that's a difference.  
14 So, it's --

15 CHAIRMAN CARR: Well, isn't it good for us  
16 to save space too?

17 MR. QUIRK: It's not quite the same land  
18 problem.

19 COMMISSIONER ROBERTS: That is where it's  
20 mindful of that problem there.

21 DOCTOR WILKINS: Yes. I think it's less of  
22 a space issue than Japan.

23 COMMISSIONER ROGERS: Is that a missile  
24 protection --

25 MR. QUIRK: Well, you do need that.

1 DOCTOR WILKINS: For missile protection  
2 regions. They turn it transverse primarily -- not  
3 just space, but the rocky coast. They have a lot of  
4 excavation --

5 CHAIRMAN CARR: Needless to say, that will  
6 be an interesting list for us to look at.

7 COMMISSIONER CURTISS: Just a quick  
8 question. Will the Japanese design include the  
9 containment overpressure feature?

10 DOCTOR WILKINS: That is still being looked  
11 at.

12 COMMISSIONER CURTISS: No decision has been  
13 made yet on that?

14 DOCTOR WILKINS: No.

15 COMMISSIONER CURTISS: Okay.

16 Sorry, Ken. Go ahead.

17 CHAIRMAN CARR: I guess I have some problem  
18 with how this is going to achieve standardization for  
19 me if I continue on with what I call business as  
20 usual. Everybody that submits me a design to certify,  
21 I certify, and I end up building all these plants out  
22 in the country. How do you see that?

23 DOCTOR WOLFE: I would think the ABWR is  
24 different than other plants that you're being  
25 presented with now.

1                   CHAIRMAN CARR:    I realize you'd like to  
2 certify on your plant, just have that the standard  
3 design.

4                   DOCTOR WOLFE:   The point I was going to make  
5 though, Commissioner, is that the plant is a detailed  
6 design.   It's had several hundred million dollars  
7 invested in it in terms of tests as well as detailed  
8 design.   It's a plant that's going to be built in  
9 Japan as a power plant.   It's one that's clearly  
10 suitable and meets all the requirements --

11                  CHAIRMAN CARR:   I realize all that but let's  
12 look -- if we get a U.S. buyer for your AL --

13                  DOCTOR WOLFE:   ABWR?

14                  CHAIRMAN CARR:   -- ABWR.   We also are coming  
15 along with passive designs.   We're coming along with  
16 three other proposed designs.   I can see us having as  
17 many, say, as eight different designs out there.  
18 While that's probably better than 52 or 112 or  
19 something, is that what you see as standardization?

20                  DOCTOR WOLFE:   Well, again, let me say.  
21 We're working on the passive design also.   Our --

22                  CHAIRMAN CARR:   I know.   That's two.

23                  DOCTOR WOLFE:   But that's several years down  
24 the pike.   The results, although we're very optimistic  
25 and enthusiastic about the design, nevertheless we've

1 got a few years of detailed design before we come up  
2 to the final design and let me say to the final cost  
3 estimate, to show that it really would be cost  
4 effective.

5 CHAIRMAN CARR: Well, is this a 40 year  
6 design or a 60 year design, the ABWR?

7 DOCTOR WILKINS: Sixty.

8 DOCTOR WOLFE: It's a 60 year design.

9 CHAIRMAN CARR: Sixty year design. So, a  
10 few years down the pike for a passive doesn't mean  
11 much. In 60 years, we're liable to have another three  
12 year designs. Standardization being the goal, I'm a  
13 little worried about if I'm really getting there.

14 DOCTOR WOLFE: Well, again, if we go back to  
15 our present situation where we have 111 plants out  
16 there, no two plants being identical, I think our  
17 thought is that the ABWR is going to be the next  
18 generation of large BWRs and they're all going to be  
19 identical. That's going to be quite different than  
20 the present situation.

21 We're looking at the 600 megawatt plant  
22 because we think there may be a requirement for  
23 smaller sizes. It's not clear whether the small or  
24 the large size, and I could give you a ten minute  
25 discussion of the differences -- we think there's an



1 application for both. So, we're looking at a small  
2 size which, of necessity, has to be different because  
3 the economics of small plants are going to be  
4 different than the large plants.

5 So, in five years, if we're successful,  
6 you're right, you're going to have three standard  
7 designs, maybe four with the combustion plant standard  
8 designs. Now, I think that's going to be what you'll  
9 have in the next decade because those are plants that  
10 meet utility requirements and they meet your  
11 requirements in terms of using technology which the  
12 NRC is well acquainted with.

13 How many of each type will be built is a  
14 question I can't answer here, but it seems to me that  
15 there are four plants which have been reviewed by you  
16 in detail which will be built as standard plants, if  
17 all of them are built. I think I share your kind of  
18 question. I'm not sure that all four plants will  
19 ultimately be built, but if they are they at least are  
20 standard plants which can be replicated and which can  
21 be operated effectively, much more effectively than  
22 the present hundred different plants that we have out  
23 there.

24 CHAIRMAN CARR: Of course they're not going  
25 to go away, so we'll have 116 different designs.

1 DOCTOR WOLFE: You'll have those too.

2 CHAIRMAN CARR: The next question is, what  
3 do you --

4 DOCTOR WOLFE: I think -- let me make a  
5 point though. I think those will go away quicker if  
6 we can get decent standardized designs here so the  
7 utilities can build them with assurance.

8 CHAIRMAN CARR: Well, I'm not saying  
9 standardization won't be a few kinds of plants. I  
10 just wanted to get your opinion of that.

11 This next question is, what do you perceive  
12 as the value in completing the NRC review of the EPRI  
13 Requirements Document for evolutionary plants?

14 DOCTOR WOLFE: Well, we'd like to see it  
15 completed it because we think it provides a good base  
16 for those who are designing a new plant. We think  
17 that the EPRI Requirements Document by itself does not  
18 provide a means of licensing new plants. As Dan  
19 Wilkins has just mentioned, as you go through the  
20 actual details of an honest to God plant, you find  
21 things that you can do that really make, we think,  
22 significant safety and perhaps other improvements that  
23 you don't see when you do it generically.

24 CHAIRMAN CARR: Well, but at that point do  
25 you change the EPRI Requirements Document or do you

1 change the plan?

2 DOCTOR WOLFE: Well, I think what you do is  
3 you use the EPRI Requirements Document as a major  
4 guideline and where you see that there are reasons to  
5 depart from the EPRI guidelines, you depart and  
6 explain why you depart.

7 CHAIRMAN CARR: But then if that's such a  
8 valuable idea, why wouldn't you change the guidelines?

9 DOCTOR WOLFE: Well, I think you might  
10 change the guidelines ultimately. I think it's an  
11 iterative procedure. Let me say, when you take the  
12 EPRI document, it tries to span the light water  
13 reactor field. So if I take the venting that we find  
14 is very, very inexpensive in the ABWR, it may, in a  
15 different design, be much more expensive and it may  
16 well be in that kind of a situation there'd be a cost  
17 benefit analysis which would say that you'd do  
18 something else. You'd find other advantages in one  
19 design over another.

20 So that the EPRI document itself might not  
21 require a venting of the containment because it's a  
22 general document, but in our case, as Dan has said, we  
23 think the venting would be required. On the other  
24 hand, it might look at what we've done and then change  
25 it's requirements if it finds that in the details

1       there are things that could be done more  
2       expeditiously.

3               CHAIRMAN CARR:   And one comment.   I would  
4       like to encourage you to take a look at the failure of  
5       the rupture disk for those two open valves.   Having  
6       participated in the failure of a rupture disk that  
7       wasn't supposed to rupture and flooding the lower  
8       level of a reactor compartment, you've got it in a  
9       water environment right next to the -- according to  
10      your diagram.

11             DOCTOR WILKINS:   No, it's in the air space.

12             DOCTOR WOLFE:    It's in the air space.

13             CHAIRMAN CARR:    But you don't think that's  
14      going to be steamy?

15             DOCTOR WILKINS:   It will be -- in normal  
16      operation, it --

17             CHAIRMAN CARR:    And on the other side of  
18      that is going to be outside cold air, the way you've  
19      got it perhaps.   All I'm saying is if that rupture  
20      disk fails, personally I want to be sure there's a  
21      manual valve shut somewhere in that so that we don't  
22      have inadvertent --

23             DOCTOR WOLFE:    Well, we've considered both.  
24      Let me say, Commissioner, you can end up now in one of  
25      these philosophical debates.

1 CHAIRMAN CARR: I can join the argument.

2 DOCTOR WOLFE: The point that Dan made is  
3 that the operator doesn't have to do anything. Now,  
4 we've also considered keeping one of those valves  
5 closed and so the operator just has to push a button.

6 CHAIRMAN CARR: Well, you can put it outside  
7 the wall if you want to, but I feel like initiation of  
8 venting a containment is going to be a very tough  
9 decision for anybody to make, especially with the  
10 margin that's usually in a containment that we really  
11 can't figure.

12 Commissioner Curtiss, I'm through.

13 COMMISSIONER CURTISS: Three quick  
14 questions.

15 DOCTOR WOLFE: Just let me make the point--

16 COMMISSIONER CURTISS: Go ahead.

17 DOCTOR WOLFE: I think the analysis that  
18 we've done so far has shown that even under the most  
19 severe accident condition where you want to rupture  
20 the disk, even then the off-site dose is less than 25  
21 R. So that if you imagine the --

22 CHAIRMAN CARR: Well, you may want to put  
23 two rupture disks.

24 DOCTOR WOLFE: Yes. No. I understand what  
25 you're saying.

1 DOCTOR WILKINS: We're looking at that  
2 issue.

3 CHAIRMAN CARR: All I worry about is that  
4 steamy environment up against that --

5 COMMISSIONER CURTISS: The complications of  
6 an issue like this that you've described, whether the  
7 operator ought to be involved or not, might be  
8 important if we were talking about  $10^{-4}$ , but we're up  
9 to  $10^{-6}$ . I guess I wonder do we even need to get to  
10 those questions, even if it is inexpensive.

11 Quick questions. The EPRI Requirements  
12 Document, as a practical matter, the evolutionary  
13 requirements document is really irrelevant for you at  
14 this point because you proceed ahead of that. We  
15 haven't completed our review of that document.

16 The question that I have is, the passive  
17 requirements document which is coming up on our screen  
18 and which could provide some benefit for those vendors  
19 that want to build passive plants, if you had your  
20 druthers, do you think from your own parochial  
21 perspective it would make sense for us to complete  
22 action on the evolutionary document or to devote our  
23 resources to getting a leg up on the passive document?

24 DOCTOR WILKINS: I think, first of all, the  
25 evolutionary document has had a big impact on our work

1 already and it has come from our working directly with  
2 EPRI as opposed to coming from your review of the  
3 requirements document. But we have --

4 COMMISSIONER CURTISS: Yes, but if it's  
5 already been accomplished or achieved today --

6 DOCTOR WILKINS: Yes, but I think it's --

7 COMMISSIONER CURTISS: Is there any future  
8 benefit for you?

9 DOCTOR WILKINS: I think that to the extent  
10 there are still issues open, that there is an  
11 opportunity by proceeding with both the requirements  
12 document and the certification in parallel to close  
13 those issues and to have the right balance between  
14 generic and plant-unique content in the solutions that  
15 are reached. So, we think both should go forward.

16 I would also say that we think there is  
17 merit in the requirements and the design proceeding in  
18 parallel. I've been involved in reactor designs for  
19 many years and you always try to write down the  
20 requirements first. You ought to do that. But you  
21 always find that when you try to implement them into  
22 the design, you have to go back and take another look  
23 at the requirements. We think one of the advantages  
24 of the current program is the fact that you do have  
25 both the requirements and the design on the table

1 together and can look at both of them.

2 COMMISSIONER CURTISS: Just one final  
3 question. You'll be the first design that goes  
4 through our Part 52 process. You've had a chance now  
5 to take a look at the rule. It's been on the books  
6 for some time. Based upon what you've seen and where  
7 you're headed, are there particular soft spots or  
8 potential glitches that you think exist from your  
9 perspective in terms of the design certification part  
10 of that rule, what has to be included in the design,  
11 procedural glitches that you think we ought to be  
12 especially sensitive to?

13 DOCTOR WOLFE: We're reviewing those with  
14 our consultants on this matter, Mark Rowden for  
15 example, and we think we have a path to meet your Part  
16 52 regulations. It will be the first one, and so  
17 there will be give and take between you and your staff  
18 and us. But we think we have a path that --

19 COMMISSIONER CURTISS: You haven't  
20 identified any problems yet, to date?

21 DOCTOR WOLFE: No insurmountable problems.  
22 Joe?

23 DOCTOR WILKINS: I would say we're not very  
24 far into it yet either.

25 COMMISSIONER CURTISS: That's all I have.



1 Thank you.

2 COMMISSIONER ROGERS: I'd just throw in one.  
3 That is, in your view, what do you think the role of  
4 the EPRI Design Requirements Document would be after  
5 this -- assuming your design is all approved and so on  
6 and so forth? What do you think the role of that  
7 would be, as far as you're concerned, in the future?

8 DOCTOR WILKINS: Well, the EPRI Requirements  
9 Document could very well become the bid spec for  
10 utilities to use in ordering future plants. Our view  
11 is that the utilities, through that document, are  
12 putting down their requirements. Over on the other  
13 side you have the NRC structure and the regulatory  
14 requirements and our job as certification applicant is  
15 to meet both. Certainly there is merit to having a  
16 standard utility bid specification for future plants.  
17 In fact, one of the reasons we have 112 plants, all  
18 different, is that there wasn't a standard utility bid  
19 specification.

20 DOCTOR WOLFE: But I think after we finish  
21 our procedures and clearly we begin producing ABWRs, I  
22 would say if we make changes in the ABWR for future  
23 uses, we would be looking at the requirements document  
24 and either suggesting they change the requirements  
25 document or making sure we conformed with it. But I

1 think there will be -- and this is a judgment -- there  
2 will be people following us who will then start with a  
3 base of requirements which I think provides a  
4 uniformed way to develop a plant.

5 As Dan said, we did use the -- we were part  
6 of the EPRI Requirements Document. We helped  
7 formulate it and we did follow it and we found it very  
8 useful in getting the initial design through.

9 CHAIRMAN CARR: When I look at your chart  
10 here and hear your words, are you really telling me I  
11 don't need an EPZ anymore?

12 DOCTOR WOLFE: That's what we're trying to  
13 tell you.

14 CHAIRMAN CARR: Okay. I just wanted to make  
15 sure I was reading the message.

16 DOCTOR WOLFE: That's correct.

17 CHAIRMAN CARR: Any other comments,  
18 questions?

19 Well, I'd like to thank the representatives  
20 of General Electric Company for coming in today to  
21 brief the Commission on the status of the advanced  
22 boiling water reactor design certification program.  
23 The perspective you've provided will help the  
24 Commission making an informed decision as to the  
25 priorities to be applied in performing NRC's review of

1 specific plant designs, as well as the EPRI Design  
2 Requirements Documents.

3 If there are no other comments, we stand  
4 adjourned.

5 (Whereupon, at 11:16 a.m., the above-  
6 entitled matter was concluded.)  
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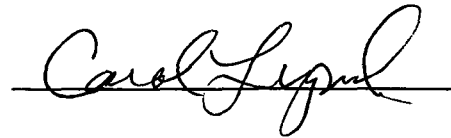
CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting  
of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING BY GENERAL ELECTRIC ON THE  
ADVANCED BWR STANDARD PLANT REVIEW  
PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: NOVEMBER 1, 1989

were transcribed by me. I further certify that said transcription  
is accurate and complete, to the best of my ability, and that the  
transcript is a true and accurate record of the foregoing events.



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## SCHEDULING NOTES

Title: Briefing by General Electric on the Advanced BWR  
Standard Plant Review

Scheduled: 10:00 a.m., Wednesday, November 1, 1989 (OPEN)

Duration:            Approx 1 hr

Participants: General Electric 60 mins

- Dr. Bertram Wolf  
Vice President and  
General Manager of GE Nuclear Energy
  - Dr. Daniel R. Wilkins  
ABWR Program General Manager
  - P.W. Marriott, Manager  
Licensing and Consulting Services
  - Joe Quirk  
Program Manager
- Introduction
  - Status of GE ABWR  
standard plant review
  - Severe accident design  
and other changes

# **ABWR Certification Program Progress Report**

**Presented to**

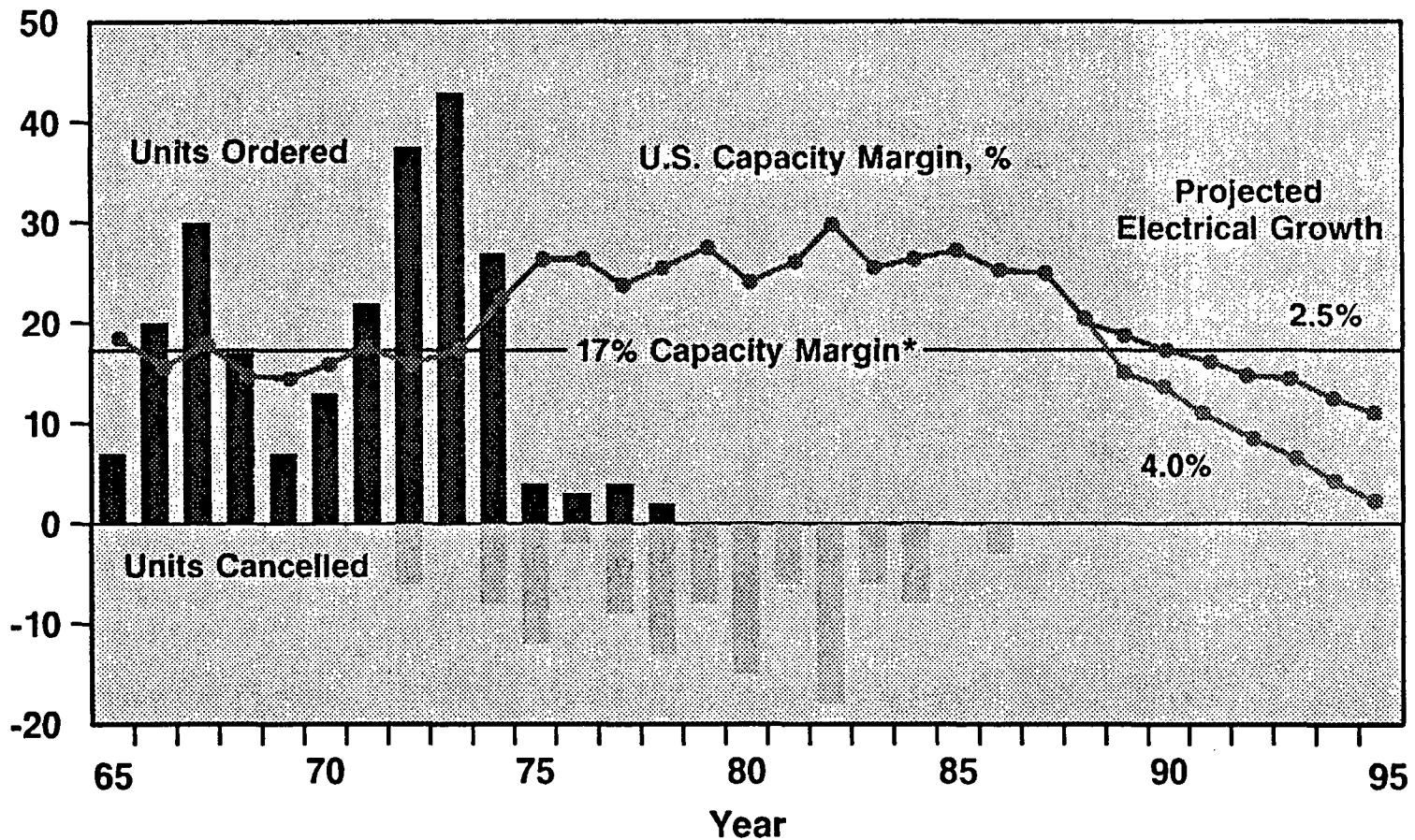
**Nuclear Regulatory Commission**

**November 1, 1989**

**Rockville, Maryland**

**GE Nuclear Energy**

# U.S. CAPACITY MARGIN AND NUCLEAR ORDERS



Source: U.S. Council for Energy Awareness, 6/89

\*Minimum Required for Reliability

## **Advanced BWR (ABWR)**

- ♦ **1350 MWe**
- ♦ **World-class design by International Team**
  - **Best proven features**
- ♦ **Development complete - \$ 250 M**



## **Advanced BWR (ABWR) (cont.)**

- ♦ **U.S. certification underway**
  - **First U.S. standard plant**
  - **Cooperative DOE/EPRI/GE effort**
  - **Demonstrate standard plant licensing process**
  - **Complete 1991**

## **ABWR In Japan**

- ♦ **ABWR is next generation standard BWR for Japan**
- ♦ **Lead plants committed by Tokyo Electric Power Co.**
  - **Kashiwazaki 6 & 7**
  - **Licensing application**                      **1988**
  - **K-6 commercial operation**              **1996**
  - **K-7 commercial operation**              **1998**

## **ABWR In Japan (cont.)**

- ♦ **GE/Hitachi/Toshiba joint venture**
  - **GE to supply nuclear steam supply, fuel, and turbine generators**
- ♦ **U.S./Japanese regulatory interaction**

## ABWR Certification Program Scope and Schedule

### Nuclear Island

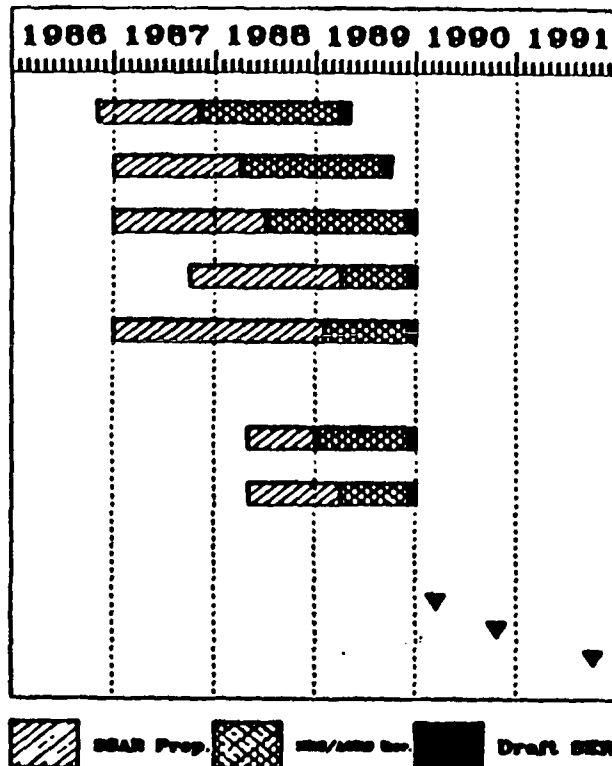
- Reactor & Safety Systems
  - Chapters 4, 5, 6 & 15
- Plant Arrangement
  - Chapters 1, 2 & 3
- I&C, Auxiliary Systems & QA
  - Ch's 7-9, 11-14, 17
- Tech Specs & Emerg. Proc.
  - Chapters 16 & 18
- Severe Accidents
  - Chapter 19

### Remainder of Plant

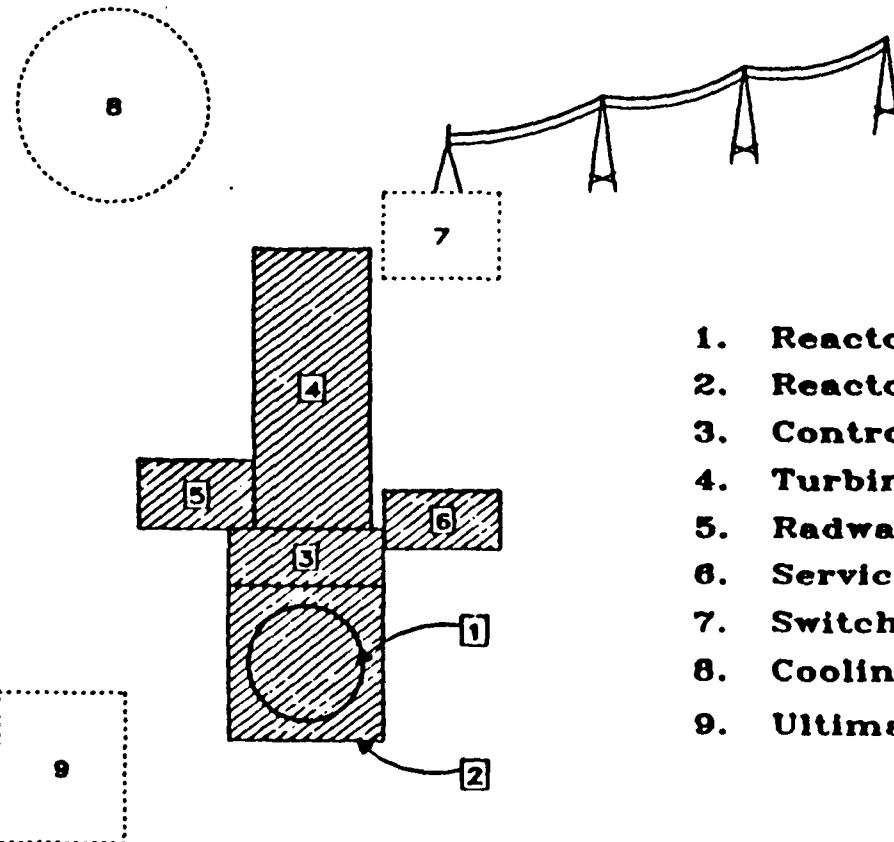
- Turbine Island
  - Ch. 10, Parts of other Chs
- Radwaste Facility
  - Ch. 11, Parts of other Chs

### Key Milestones

- Final SER Issued
- FDA Issued
- Certification Issued



## SCOPE OF ABWR SSAR



1. Reactor containment
2. Reactor building
3. Control building
4. Turbine building
5. Radwaste building
6. Service building
7. Switchyard
8. Cooling tower
9. Ultimate heat sink

## **ABWR Certification Program Tasks**

- ♦ **Licensing basis - completed in 1987**
  - **Developed acceptance basis for review**
  - **Defined review procedures and interfaces**
  - **Established review schedule**
- ♦ **Preparation and submittal of SSAR - in process**
  - **Prepare and submit SSAR**
  - **Respond to NRC Questions**
  - **Participate in ACRS meetings**
  - **Obtain FDA**
- ♦ **Design certification - to be initiated in 1990**
  - **Rulemaking proceeding**
  - **Obtain certification**

## **Status of Regulatory Briefings and Meetings**

### **Commission Briefings**

**Sept. 19, 1986  
Apr. 30, 1987  
Jan. 26, 1988  
Jan. 24, 1989  
Nov. 1, 1989**

### **ACRS Subcommittee Meetings**

**Jan. 7, 1987  
Jun. 1, 1988  
Nov. 15-16, 1988  
May 10-11, 1989  
Oct. 31, 1989**

### **ACRS Full Committee Meetings**

**Jan. 7, 1987  
Mar. 6, 1987  
Jan. 7, 1988  
Aug. 11, 1989**

### **NRC Management Meetings**

**Oct. 16, 1986  
Nov. 21-22, 1987  
Mar. 13-14, 1989**

## **Status of SSAR Submittals**

<b><u>Description</u></b>	<b><u>Submittal Date</u></b>
Reactor and Safety Systems	9/29/87
Plant Arrangement & Criteria	3/29/88
I&C, Auxiliary System & Quality Assurance	6/29/88
Turbine Island	12/30/88
Radwaste, Human Factors & Reliability	3/31/89
Technical Specifications	6/23/89
Severe Accident Evaluation	7/28/89

**ALL SSAR CHAPTERS NOW 98% COMPLETE**



## **Status of Response to NRC Request for Additional Information (RAI)**

- ♦ **598 NRC Questions Received**
- ♦ **524 Questions Answered**

**ACTIVE DIALOGUE CONTINUING**

## **ABWR ACCIDENT PREVENTION (P) AND MITIGATION (M) FEATURES**

- ♦ **SYSTEM DYNAMICS**
  - INCREASED THERMAL MARGINS P
  - STABILITY ASSURED BY DESIGN P
- ♦ **REACTOR PRESSURE VESSEL ASSEMBLY**
  - NO LARGE NOZZLES BELOW CORE P
  - REDUCED VESSEL FLUENCE P
- ♦ **CONTAINMENT STRUCTURES**
  - INTEGRATED CONTAINMENT/REACTOR BUILDING P/M
  - LOWER LOCA LOADS M
- ♦ **MATERIALS/WATER CHEMISTRY**
  - PROVEN MATERIALS P
  - HYDROGEN WATER CHEMISTRY P

## **ABWR ACCIDENT PREVENTION (P) AND MITIGATION (M) FEATURES**

### **• SYSTEM DESIGN**

- |                                |     |
|--------------------------------|-----|
| - NO FUEL UNCOVERY DURING LOCA | P   |
| - THREE SAFETY DIVISIONS       | P/M |
| - DIVERSE ECCS SYSTEMS         | P   |
| - DIVERSE CONTROL ROD          | P   |
| - NO SCRAM DISCHARGE VOLUME    | P   |
| - INERT CONTAINMENT            | M   |
| - FAULT TOLERANT CONTROL       | P   |
| - FULL 2 OUT OF 4 SAFETY LOGIC | P   |

## **ABWR ACCIDENT PREVENTION (P) AND MITIGATION (M) FEATURES**

### **•SEVERE ACCIDENT DESIGN ENHANCEMENTS**

- |  |   |
|--|---|
| - COMBUSTION TURBINE                     | P |
| - DRYWELL FLOODER                        | M |
| - AC INDEPENDENT COOLING WATER           | M |
| - CONTAINMENT OVERPRESSURE<br>PROTECTION | M |

**BALANCED APPROACH TO  
PREVENTION AND MITIGATION**

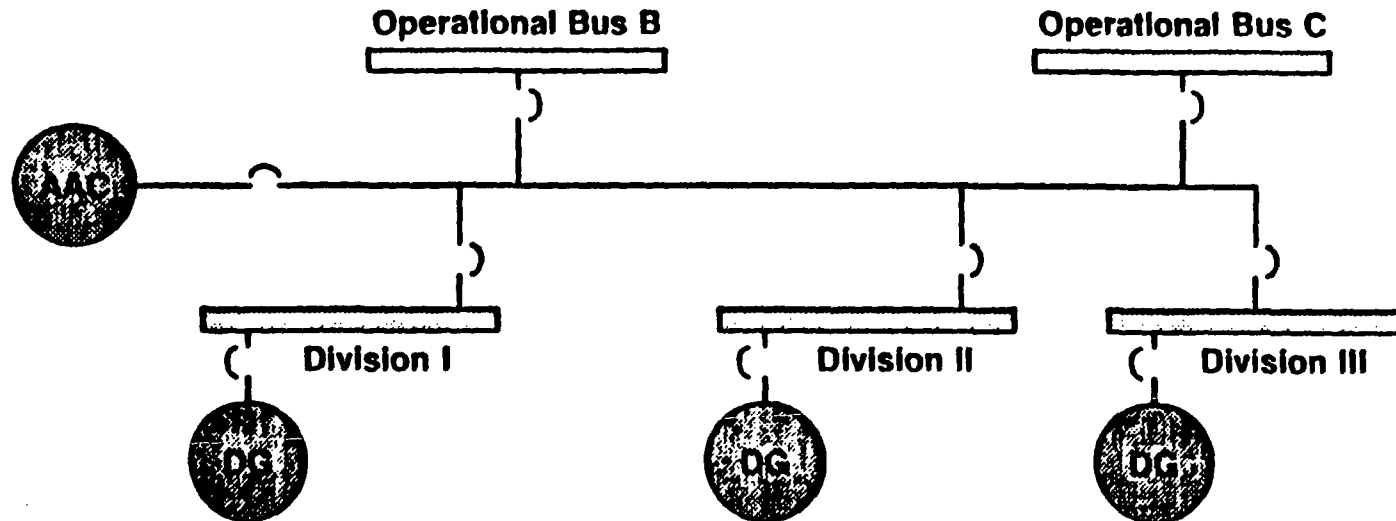
# SEVERE ACCIDENT ANALYSIS RESULTS

## Summary

Subject	Goal	Result
Core Damage Frequency	$<10^{-5}$ Per Yr.	$4 \times 10^{-7}$ Per Yr.
Conditional Containment Failure (25 rem) Probability	$<0.1$	0.004
Offsite Dose at 1/2 Mile/ $10^{-6}$ Probability	$<25$ rem	0

**All Goals Met**

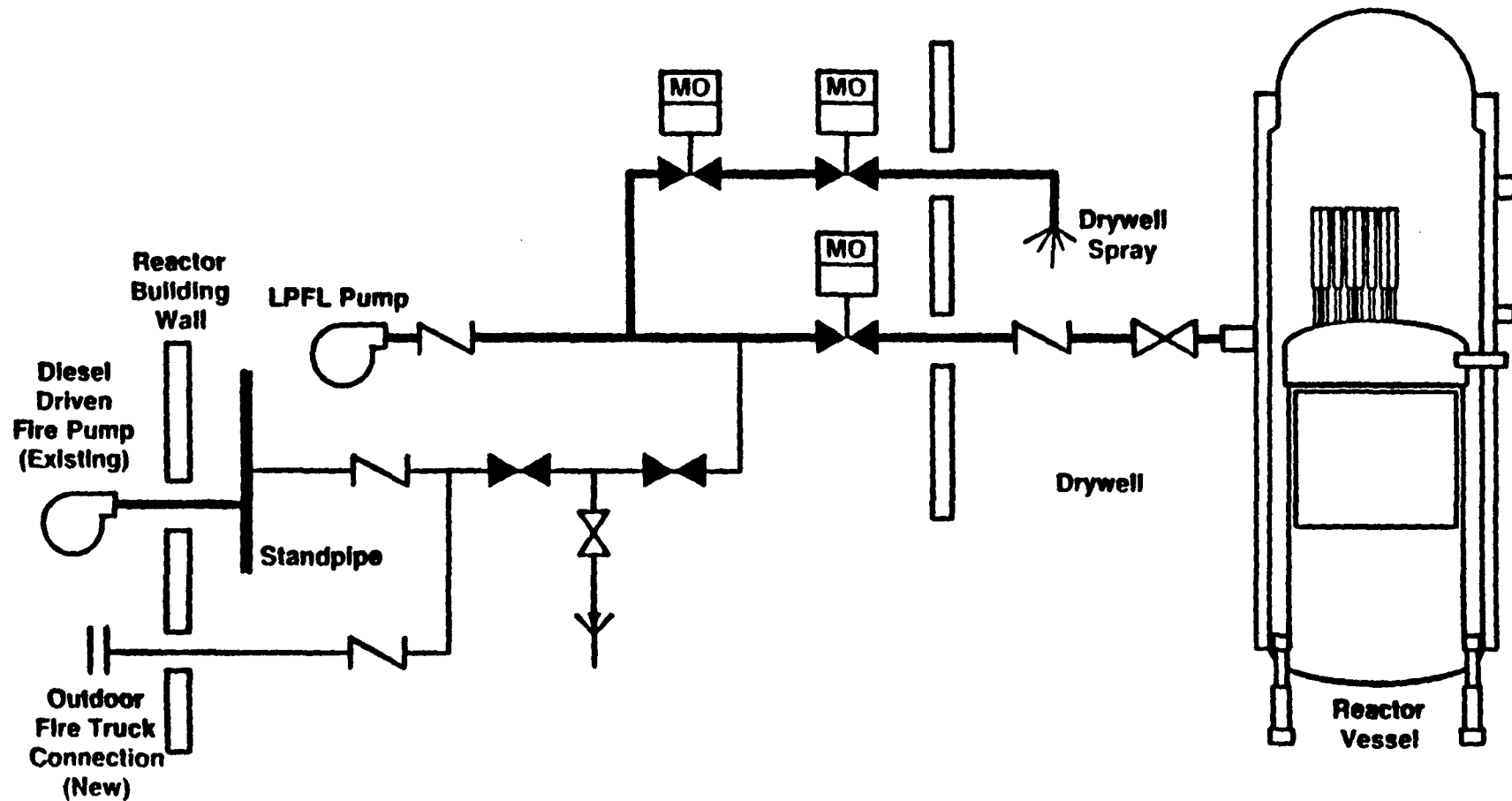
## GAS TURBINE - ALTERNATE AC



- **Operation:**
  - AAC Backs up Emergency Diesel Generators
- **Benefits:**
  - Reduces Frequency of Station Blackout in Internal Events Analysis

# AC INDEPENDENT WATER ADDITION

-18-



# **AC INDEPENDENT WATER ADDITION**

- **EPRI-ALWR Requirements:**
  - **Connection to Decay Heat Removal Lines for Introduction of Water to Drywell Independent of Normal Systems**
- **Operation**
  - **For Addition to Reactor Vessel: If No High Pressure Core Cooling and No Low Pressure Injection Pumps Available, Manually Depressurize Reactor Vessel. Manually Close One, Open Three Valves to Admit Fire Water**
  - **Accident Mitigation: If Not Available in Time to Prevent Core Damage/Vessel Failure, Adds Water to Containment, Slows Pressure Rise**



## **AC INDEPENDENT WATER ADDITION**

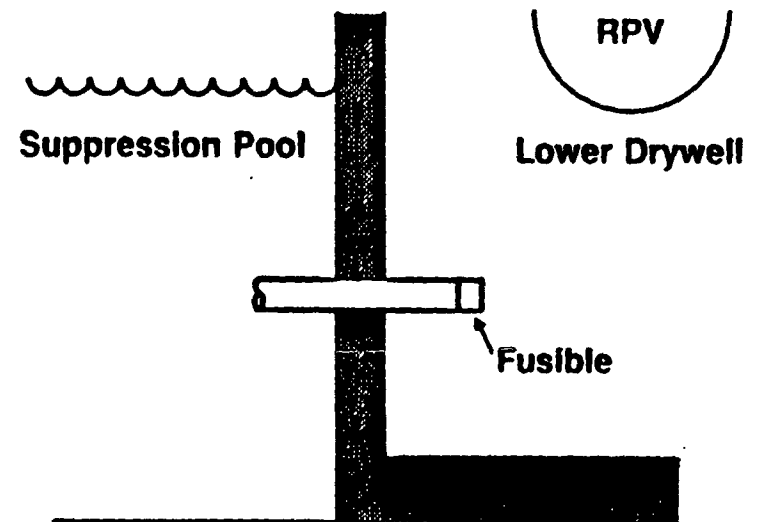
- **For Drywell Spray: If Reactor Vessel Melt Occurs at High Pressure and Normal Drywell Spray Is Not Available, Manually Close One, Open Four Valves to Admit Fire Water to Drywell Spray. Mitigates Potential for High Upper Drywell Temperature**

### **Benefits**

- **No Dependence on AC Power. Adds Reliability to Low Pressure Injection and Drywell Spray Function**
- **Seismically Qualified System with High Capability**

# LOWER DRYWELL FLOODER

- Required by EPRI-ALWR Requirements
- Operation
  - High Drywell Temperature After Vessel Failure
  - Melts Fusible Plug
  - Suppression Pool Water Flows to Drywell
- Benefits
  - Early Water Addition. Very Reliable
  - High Seismic Capability
  - Quenches Corium
    - Stops Core-Concrete Reaction
    - Reduces Drywell Temperature, Leakage Potential



## **HYDROGEN GENERATION**

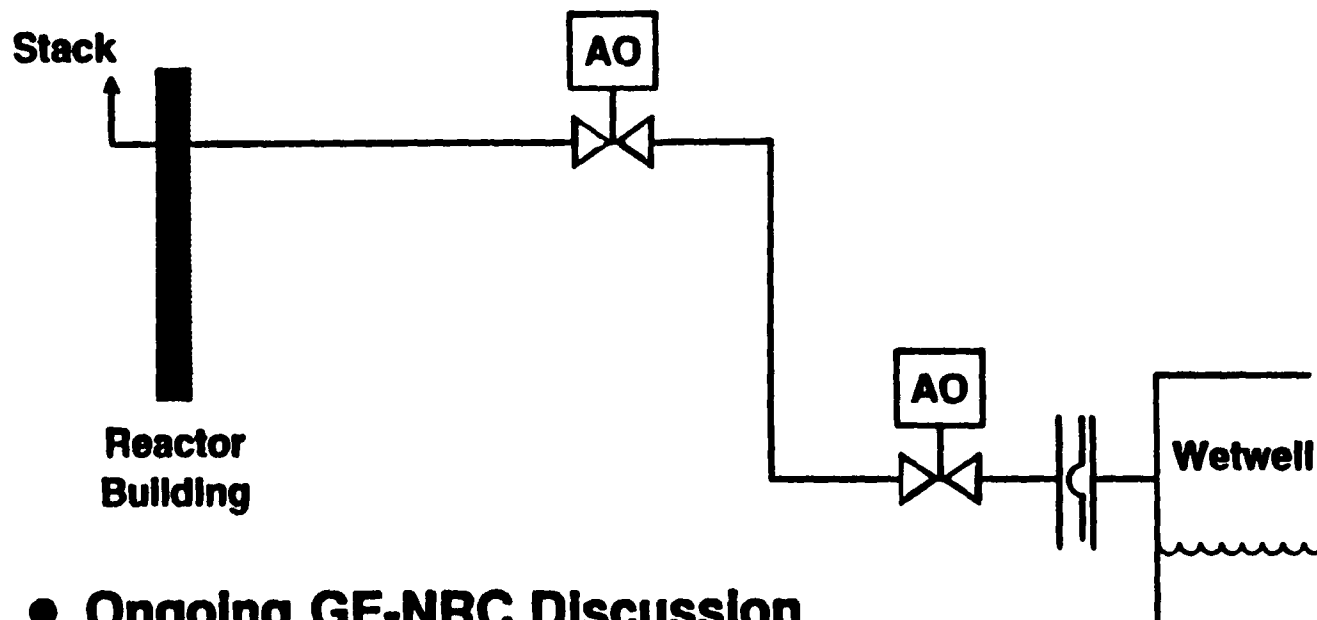
- ♦ **NRC REGULATIONS REQUIRE MEASURES TO ACCOMMODATE HYDROGEN GENERATED FROM REACTION OF EQUIVALENT OF 100% METAL (ZIRCONIUM IN ACTIVE FUEL CLAD) AND WATER**
- ♦ **EPRI ALWR REQUIREMENTS PROGRAM TECHNICAL SUBMITTALS TO NRC DEMONSTRATE A DESIGN BASIS OF 75% METAL-WATER**
- ♦ **GE BELIEVES 75% METAL-WATER DESIGN BASIS IS CONSERVATIVE**

## **HYDROGEN GENERATION**

- ♦ **DIFFERENCE BETWEEN 75 AND 100% METAL-WATER IS INCONSEQUENTIAL FOR ABWR (BECAUSE OF ITS INERTED CONTAINMENT)**
- ♦ **GE MEETING EXISTING NRC REGULATIONS (i.e. 100%) ON ABWR**
- ♦ **GE CAN EASILY ADOPT EITHER BASIS SINCE IT DOES NOT IMPACT THE DESIGN**

**INCONSEQUENTIAL ISSUE FOR ABWR**

# CONTAINMENT OVERPRESSURE PROTECTION



- Ongoing GE-NRC Discussion
- Operation
  - At Pressure Above Design Pressure and Below Capability Rupture Disks Open
  - Later, Operator Closes Isolation Valves to Regain Control of Containment Integrity

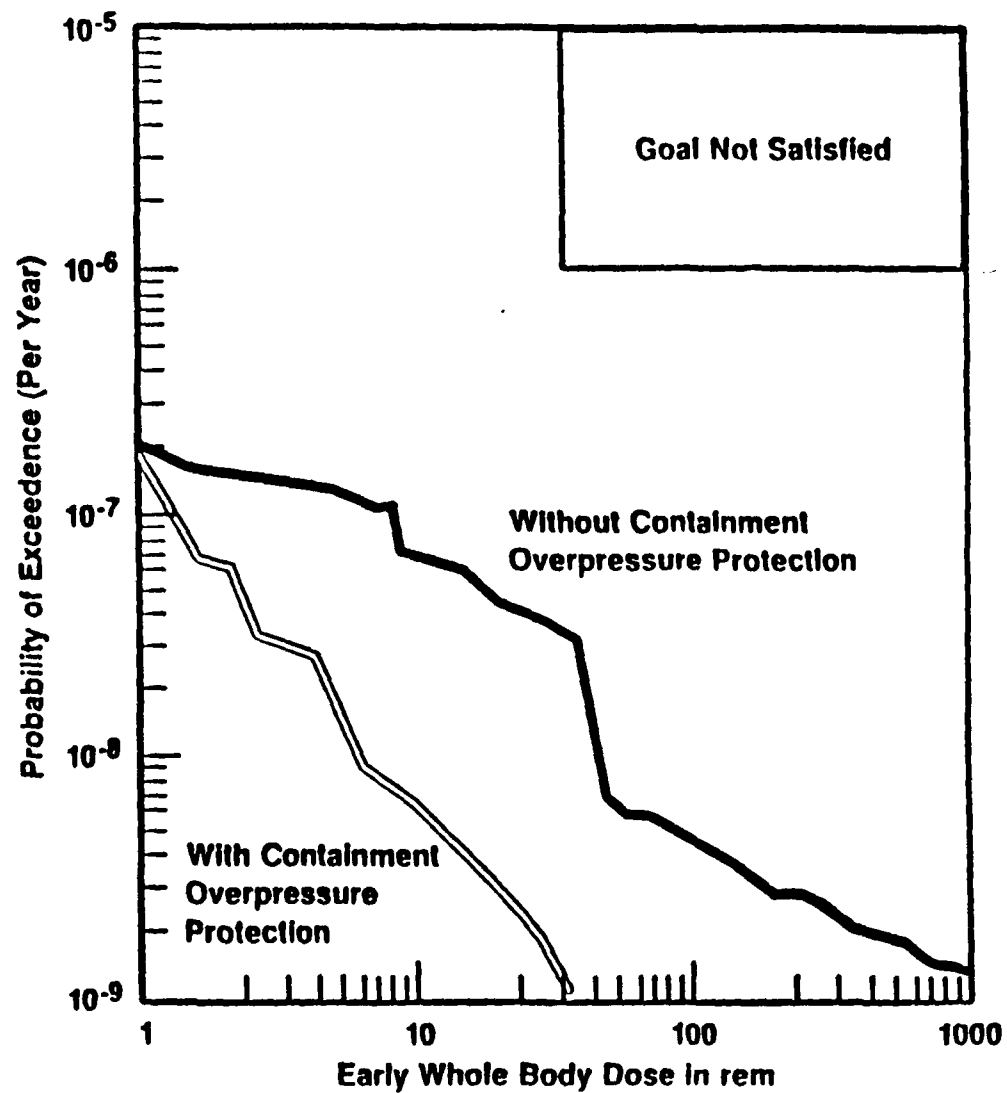
# **CONTAINMENT OVERPRESSURE PROTECTION**

- **Benefits**

- **Passive/“Never” Used/Can’t Be Misused**
- **Insures Benign Failure: Release Scrubbed by Suppression Pool, Elevated Release. Virtually Eliminates Dose  $>25$  rem**
- **No Loss of Core Cooling Water**
- **High Seismic Capability**
- **Low Failure Probability**

-25-

# WHOLE BODY DOSE AT 1/2 MILE vs. PROBABILITY OF EXCEEDENCE



# **ABWR PASSIVE SEVERE ACCIDENT MITIGATION**

## **ABWR Passive Features Which Mitigate Severe Accidents**

- **Inerted Containment**
  - **Hydrogen Control**
- **Lower Drywell Flood Capability**
- **Suppression Pool - Fission Products Scrubbing and Retention**
- **Containment Overpressure Protection**

**Public Safety Ensured by  
Simple, Passive Features**



## **SUMMARY**

- ♦ **GE ABWR Certification on Track**
  - **NRC review nearing 3/4 point**
  - **NRC current schedule consistent with DOE FDA milestone of September 30, 1990**
- ♦ **ABWR meets all severe accident goals**
- ♦ **Remaining actions prior to certification**
  - **Outstanding SSAR portions**
  - **Tests, Inspections, Analyses and Acceptance Criteria**
  - **Response to NRC Questions**

Statement of  
Dr. Bertram Wolfe  
Vice President and General Manager  
GE Nuclear Energy  
before the  
U.S. Nuclear Regulatory Commission  
November 1, 1989

## INTRODUCTION

We appreciate this chance to meet with the NRC on the GE ABWR Certification Program. This is our fifth meeting with the NRC since the program began in late 1986. The program is progressing well and is still basically on target. Dr. Wilkins will give you a status report shortly. First, however, I want to address several questions that have been the subject of recent discussions among the NRC, NRC Staff and groups representing the industry.

## U.S. MARKET FOR EVOLUTIONARY LWR

The first is the question of whether there is a U.S. market for the evolutionary LWR. My answer is: I think there will be. I can tell you that U.S. utilities, government and industry are making major investments in the evolutionary LWR as the best way to provide our country with a nuclear option when new base load commitments are needed.

Utilities will need to commit new base load plants in the 1990's. The chart shows that for the past 15 years or so, since the Arab oil embargo pushed energy costs and load growth was cut in half, there has been an excess of electrical generating capacity in the U.S. This led to no new nuclear commitments and in fact cancellation of many nuclear as well as fossil units. This situation is ending, however. Electrical brownouts occurred in the Eastern U.S. during the past two summers, and new base load commitments will be needed in the early 1990's to avoid electrical shortages on a national scale. Estimates for new generating capacity needed by the end of the century range from 100 to 200 GWe.

There are no perfect energy sources. Environmental issues including air pollution, the greenhouse effect, acid rain and oil spills are receiving front page attention, and the public is becoming increasingly aware of the risks of burning fossil fuels. In addition there is increasing concern over our rising dependence on imported oil, which now constitutes 40% of our oil supply, and subjects us to the vagaries of Mid East governments.

The coming need for power, and the rising importance of environmental and energy security issues are creating a renewed interest in the revival of nuclear power. This is why U.S. utilities, government and industry are investing in the ALWR -- in the near term, the evolutionary ALWR -- to ensure the option is available when the difficult choices must be made.

In GE's case, our ABWR has several hundred million dollars invested in its design and development by GE and our worldwide associates. It has been adopted as the next generation standard BWR in Japan, and a two unit lead

project has been committed by the Tokyo Electric Power Company. We are seeking NRC certification of the ABWR design because we believe it could be an excellent plant for U.S. application -- not just to support our overseas business. With the serious energy problems facing the U.S., we believe it important that the American public not have excluded from them meaningful options which could ameliorate the problems.

Perhaps the most important factor governing whether utilities will be able to turn to nuclear to fill their future needs will be the existence of NRC certified standard designs. Lead time for design, development and certification is on the order of five years or longer, and it is unlikely that any utility will order a nuclear unit unless it is certified in advance. This necessitates that we conduct the design and certification work now as a precondition to any market need.

Further -- and importantly -- the ABWR certification proceeding provides both the occasion and the opportunity for a working demonstration of the effectiveness, predictability and timeliness of a major element of the Commission's Part 52 standardization and licensing regulations. This also is a vital factor governing whether utilities will turn to nuclear as a viable option to fill their future energy needs.

#### GENERIC RESOLUTION OF SAFETY ISSUES

The second question is whether ALWR issues should be resolved generically. We believe the the answer is yes to the extent practical. We should be careful, however, not to impose generic resolution of ALWR issues where plant specific resolutions would yield better results. Our experience has been that generic resolution of ALWR issues frequently results in "least common denominator" approaches that fail to exploit plant specific opportunities which only become apparent in the context of a specific design. Certification itself represents a generic resolution of issues for a class of standard plants, and has the advantage that issues can be considered in the context of an actual design rather than in a more abstract context.

We believe the EPRI ALWR Requirements and DOE ALWR Certification Programs provide an unusually effective vehicle for considering both the generic and plant specific aspects of issues, and encourage the NRC to continue to support these programs. We recommend against generic rulemaking as an approach to the resolution of ALWR issues. Generic rulemaking would be enormously disruptive of both the ALWR Requirements Program and the ALWR Certification Programs which have major private sector investment and are nearing completion.

GE has been a participant in the EPRI ALWR Requirements Program since it's inception. The ABWR currently under review by the NRC staff is in substantial conformance with the utility ALWR Requirements. In a few areas -- most notably hydrogen control and containment overpressure protection -- we have elected to exceed the ALWR requirements. In the case of hydrogen control this was done to avoid lengthy discussion of an issue which was inconsequential for the ABWR. In the case of containment overpressure protection it was done to take advantage of unique ABWR features to provide a substantial added measure of offsite public and property protection which could be achieved at

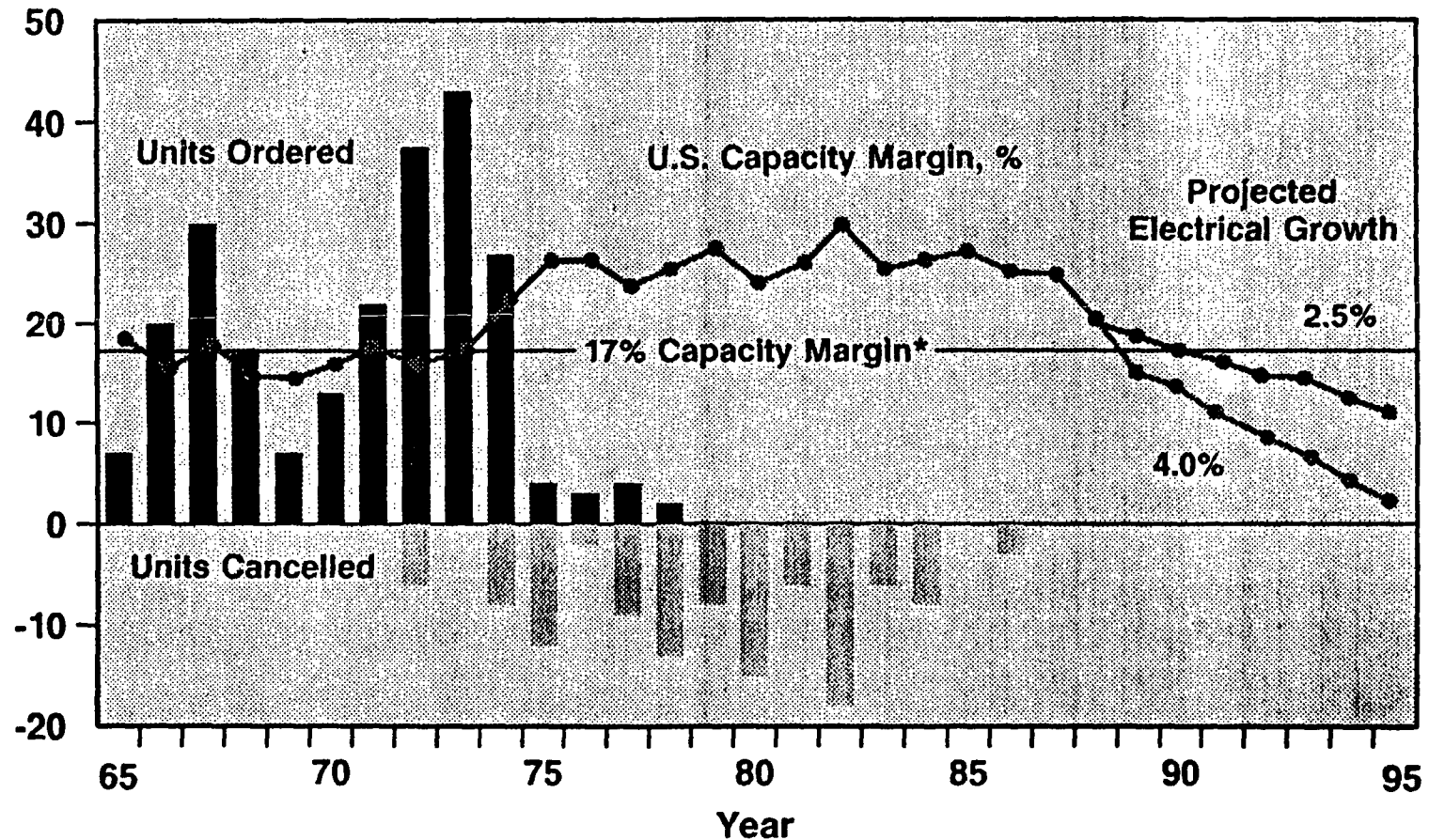
modest cost. In these two areas, we fully support the generic positions reflected in the ALWR Requirements Document while, at the same time, believing there are sound reasons for the ABWR to exceed the ALWR Requirements on a certified standard plant basis. Dr. Wilkins will discuss both of these areas in more detail in his presentation.

#### REQUEST FOR CONTINUED SUPPORT

We appreciate the very strong support the NRC and the NRC Staff have provided to the ABWR Certification Program. We believe the program has been remarkably successful to date, and is on track to provide a convincing demonstration of the benefits of the Part 52 standard plant licensing process. It is being closely followed in the U.S. and around the world as a pioneering effort which will set the direction for plant standardization in the second nuclear age. We request your continued support and I assure you that GE is fully committed to the successful completion of this program.

Thank you.

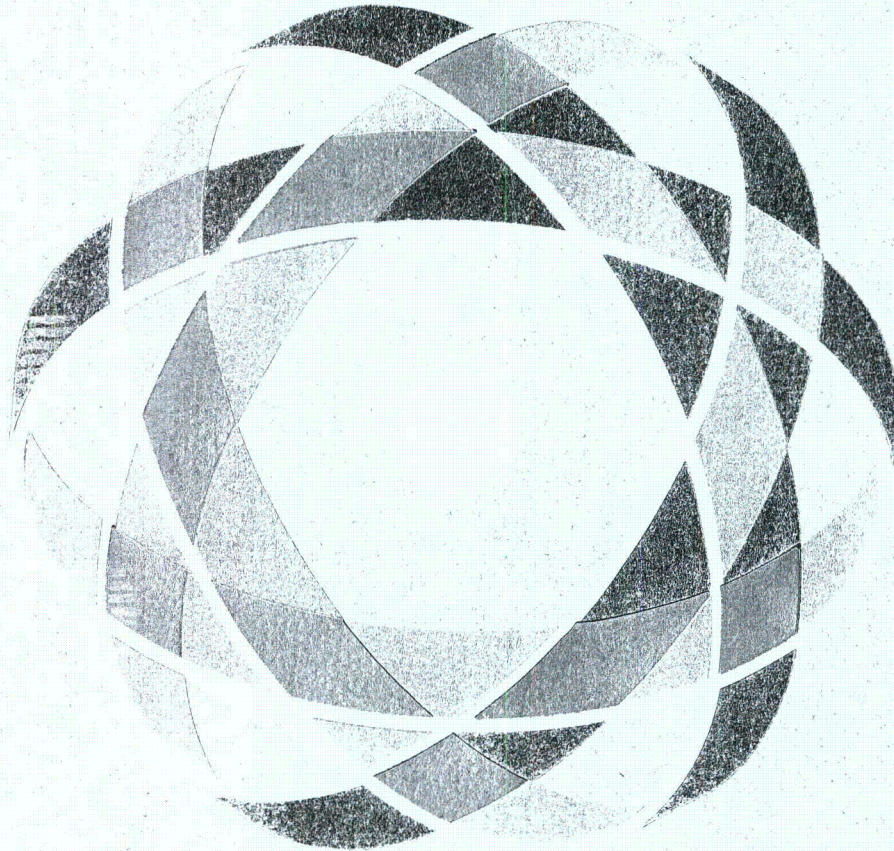
# U.S. CAPACITY MARGIN AND NUCLEAR ORDERS



Source: U.S. Council for Energy Awareness, 6/89  
 \*Minimum Required for Reliability



# Light water reactors: The next generation



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***GE Nuclear Energy***



# Advanced Light Water Reactor... the next step in meeting U.S. energy needs

*"For almost 30 years, nuclear power has proven its ability to generate large amounts of electricity without contributing to acid rain or the greenhouse effect, or increasing dependence on foreign oil."*

—David Rossin  
Former Assistant Secretary  
for Nuclear Energy  
U.S. Department of Energy

*"...actual (electricity) demand has been rising more than four percent a year for the past two years. That's why some parts of the country... are getting close to the limits of their generating capacity."*

—The Washington Post  
March 5, 1989

*"The light water reactor is miles ahead of any other competing (nuclear energy) technology in terms of design and operating experience... And, there is an extensive infrastructure in place for designing, building, operating, maintaining and licensing new light water reactors."*

—James J. O'Connor  
Chief Executive Officer  
Commonwealth Edison

Since 1984, demand for electricity in the U.S. has increased at an average of 3.5 percent per year. Peak load rose 6.7 percent in 1988. At these growth rates, our electricity demand will outgrow our present supply in the early 1990s. And yet no significant new generating capacity has been added.

Nuclear power is the second largest source of electricity in the United States, currently providing 18 percent of the country's electrical generation. It overtook oil in 1980, natural gas in 1983 and hydropower in 1984. Only coal provides more of the nation's electricity. Coal and uranium will continue to be our major sources of electricity for the foreseeable future.

Increasing public sensitivity to atmospheric pollution and the greenhouse effect, and the risks associated with dependence on foreign oil give further impetus to the use of clean and safe nuclear energy.

Surveys show that 79 percent of American adults believe nuclear energy will be important in meeting the nation's future electricity needs. They also anticipate that future nuclear reactors will perform even better than current reactors. The advanced light water nuclear power plants presented in the following pages meet these expectations with their progressive performance, economics, environmental and safety features.



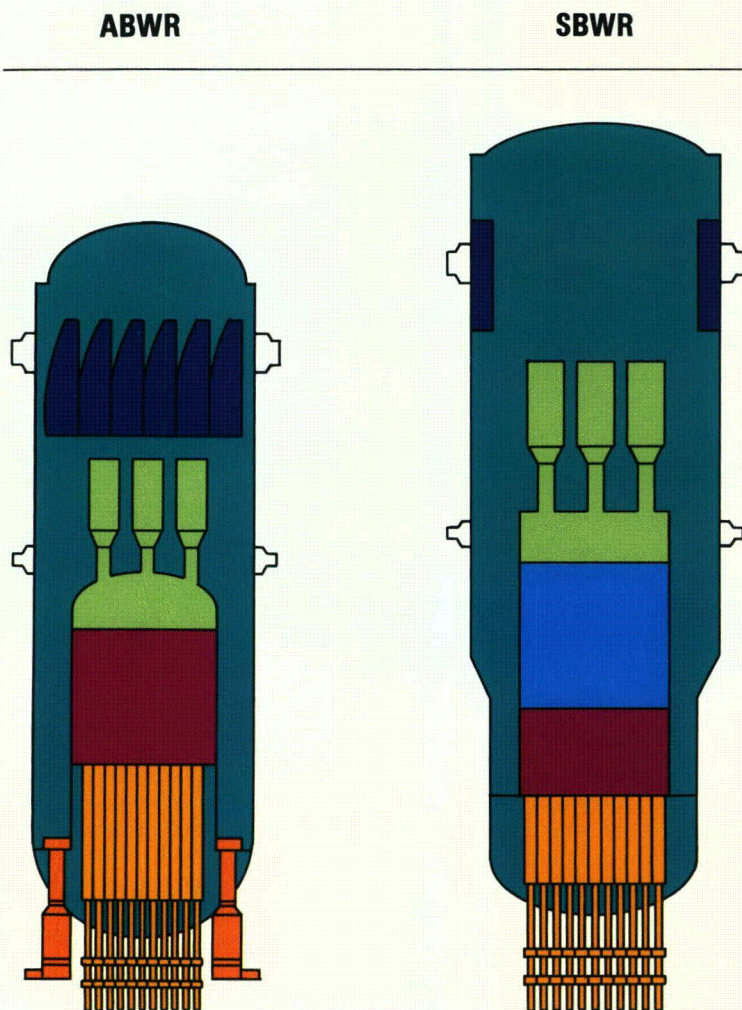
**T**he birth of peaceful nuclear power in the U.S. dates to President Eisenhower's "Atoms for Peace" program, enacted into law in 1954. Today nuclear power in the U.S. provides more electricity than was generated by all sources in 1954, and saves this country the equivalent of a billion barrels of imported oil a year. In fact, our nation's nuclear generating base consists of more than 100 light water reactors (LWRs).

The successful history of LWR development has included the application of technological advances and plant modifications to achieve prompt, satisfactory resolution of the unforeseen problems inevitable in the development and application of any new technology. Today we can build optimized light water reactors based on the three decades of experience. The Advanced Boiling Water Reactor (ABWR) and the Simplified Boiling Water Reactor (SBWR) are designs which take advantage of this experience.

Together, the ABWR and SBWR are innovative, near-term candidates for expanding electrical generating capacity in the U.S. And, they possess the features necessary to do so safely, reliably and economically.

GE was a pioneer of commercial nuclear power and a key participant in the development of the U.S. Navy nuclear submarine and surface ship propulsion programs. GE chose to develop the BWR for land-based electrical power generation because of its inherent simplicity and the advantages of its direct steam cycle design.

In response to initiatives to encourage improvements in nuclear plant design and licensing by the U.S.



*Together the ABWR and SBWR are innovative, near-term candidates for expanding U.S. electrical generating capacity.*



# ABWR and SBWR: Meeting the need for future power systems

	ABWR	SBWR
Design completion:	■ Detailed design completed.	■ Conceptual design completed.
Testing status:	■ All new systems tested full-scale.	■ Testing of new systems completed or under way.
Licensing status:	■ Scheduled for 1991 as first U.S. standard NRC-certified plant.	■ Scheduled for certification in 1995.
Deployment/project status:	■ Selected for two units at Tokyo Electric Power Company's Kashiwazaki site with '96 and '98 startups.	■ Investor ready by 1995.

*In contrast to non-LWR advanced reactors, the ABWR and SBWR are ready for near-term commercial deployment.*

Department of Energy (DOE), the Electric Power Research Institute (EPRI) and the Nuclear Regulatory Commission (NRC), GE is jointly developing two new light water reactor designs, the Advanced Boiling Water Reactor and the Simplified Boiling Water Reactor.

The ABWR is a 1356 MWe reactor developed by an international team of Boiling Water Reactor (BWR) manufacturers—from the United States, Japan and Europe—to respond to worldwide utility needs in the 1990s.

The SBWR is a 600 MWe reactor which uses natural circulation and passive safety features to minimize dependence on mechanical components and operator action.

The ABWR is the only advanced light water reactor currently being commercially deployed. It embodies the best safety and performance experience of BWRs worldwide. Its acceptance is evidenced both by its selection as the next-generation BWR in Japan, and by its progress toward becoming the first certified U.S. standard nuclear plant design.

The SBWR, four to five years later than the ABWR in its development, continues the ABWR's trend in design simplicity. In doing so, it extends the favorable economics of nuclear power generation to smaller output ratings.



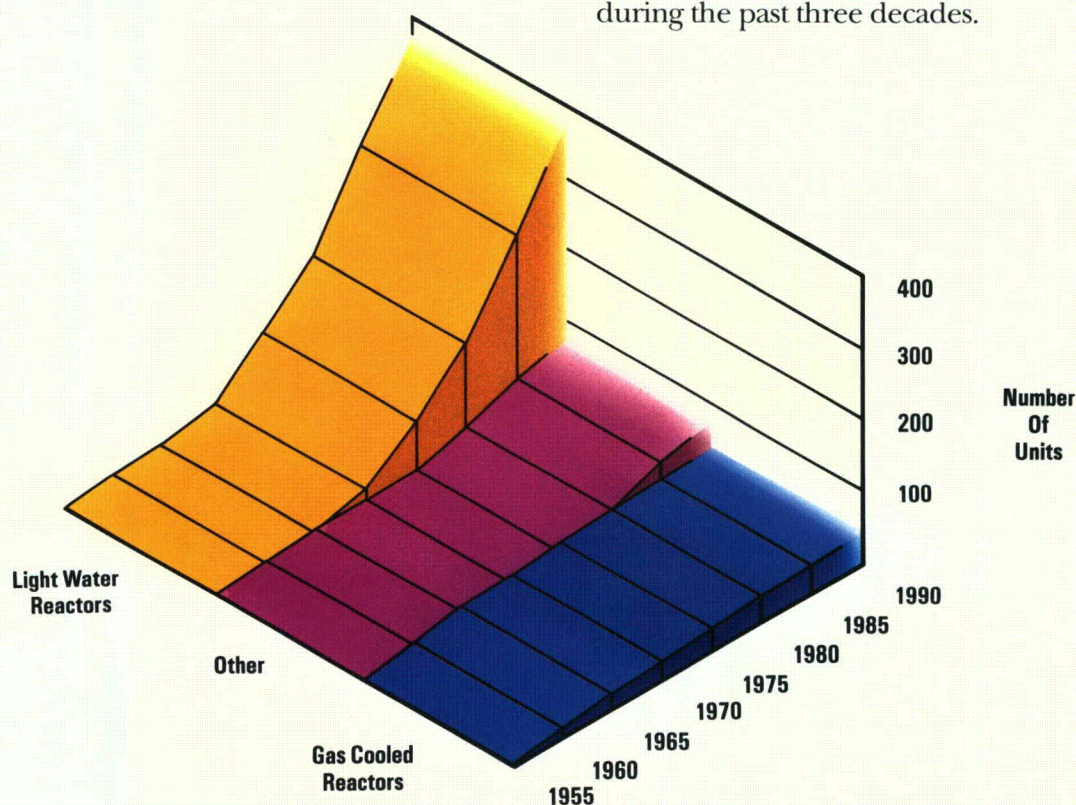
*"A majority in the nuclear power industry expect an improved version of the light water reactor to be the preferred choice for the next increment of nuclear capacity in the U.S."*

—James J. O'Connor  
Chief Executive Officer  
Commonwealth Edison

**R**esearch and development on the future LWRs are supported by the U.S. Department of Energy, the Electric Power Research Institute, major corporations, educational institutions and international teams of utilities and suppliers.

In the global nuclear power industry, LWRs are the unquestioned experience leaders in terms of design, construction, licensing and maintenance. An extensive worldwide infrastructure is already in place to support them. LWRs are the nuclear electrical generating technology choice of almost all industrialized nations. In fact, four out of five operating reactors today are LWRs.

Advanced LWRs are endorsed by U.S. utilities as the reactor technology for the next 10 to 20 years. Worldwide, LWRs have accumulated over 4600 reactor-years of operating experience during the past three decades.



*On a worldwide scale, the vast installed base of LWRs dwarfs that of all other reactor types.*



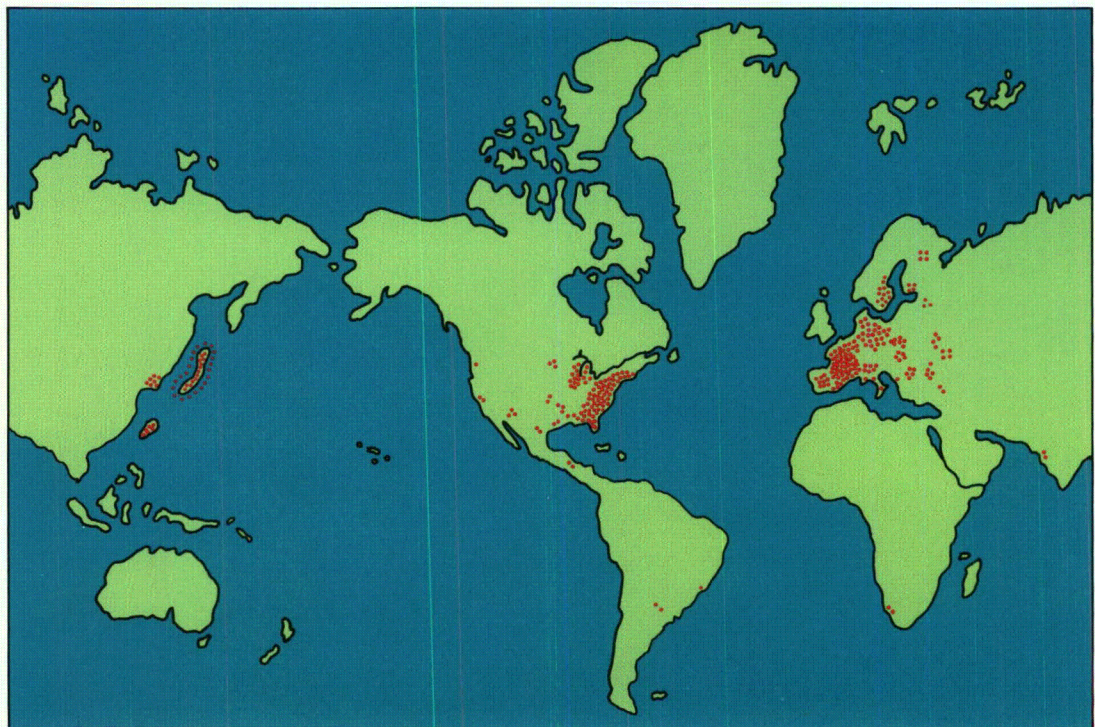
# ABWR and SBWR: Based on experience from leading LWR technology

*"Gas cooled reactors will have their place early in the next century, but only advanced water reactors will be ready within ten years, when the country will need more kilowatts."*

—Karl Stahlkopf  
Director of  
Materials and System  
Development  
Electric Power Research  
Institute

Although LWRs make up less than one-fifth of U.S. generating capacity, their performance has been noteworthy. In a recent five-year period, 14 of the top 20 performing steam power plants in the U.S. were LWRs.

Historically, unforeseen technical issues have been the nemesis of many emerging advancements. But in the LWR, such maturation issues have been encountered and solved. With a life cycle for most reactors of 40 years or more, it takes decades of experience to identify and correct unanticipated technical problems. Favorable positioning on the "learning curve" is a distinct advantage which LWRs, like the ABWR and SBWR, have over more developmental nuclear power technologies, such as gas-cooled reactors and liquid-metal fast breeder reactors.



*Light water reactors are the preferred nuclear technology in most industrialized nations.*



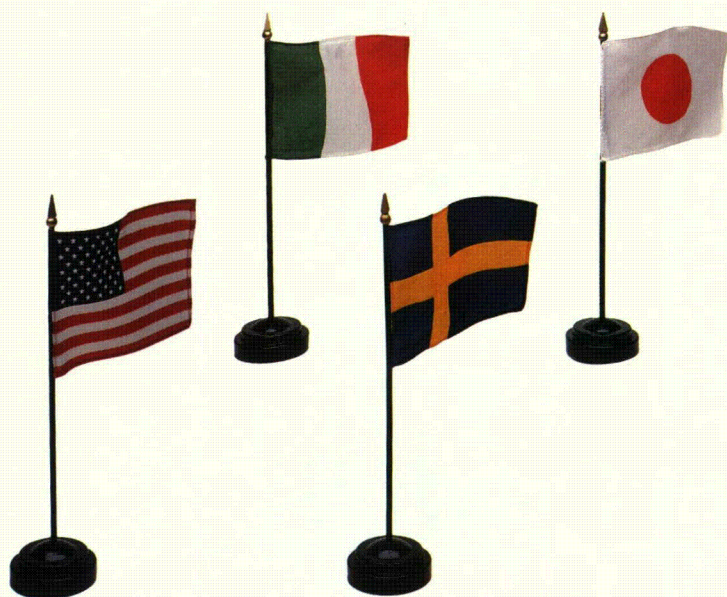
*"International cooperative programs are in place to bring into being a new generation of BWR plants. These plants will incorporate the best features and technology from the current generation of worldwide BWRs and will represent world-class standard plants to serve utility needs in the 1990s and beyond."*

—D.R. Wilkins  
General Manager  
GE Advanced BWR Programs

**A**n international cooperative effort is now under way to establish the ABWR as a world-class standard plant. Design simplification, enhanced safety and reliability margins plus lower construction, fuel and operating costs are among the attributes cited by the ABWR's worldwide support team. ABWR program objectives also include improved maneuverability and reduced occupational exposure and radwaste volume.

In 1978, when GE launched its Advanced BWR program, it assembled representatives of BWR suppliers and leading architect-engineer firms from around the world in an Advanced Engineering Team. These individuals established the basic ABWR design parameters: A reactor which takes advantage of the strongest, operationally proven features from BWR designs in Europe, Japan and the United States.

The ABWR, the first reactor to be entirely designed since the accident



*The international team of BWR manufacturers who have contributed to the ABWR includes major firms in the United States, Sweden, Italy and Japan.*



# ABWR: A world-class reactor from an international team

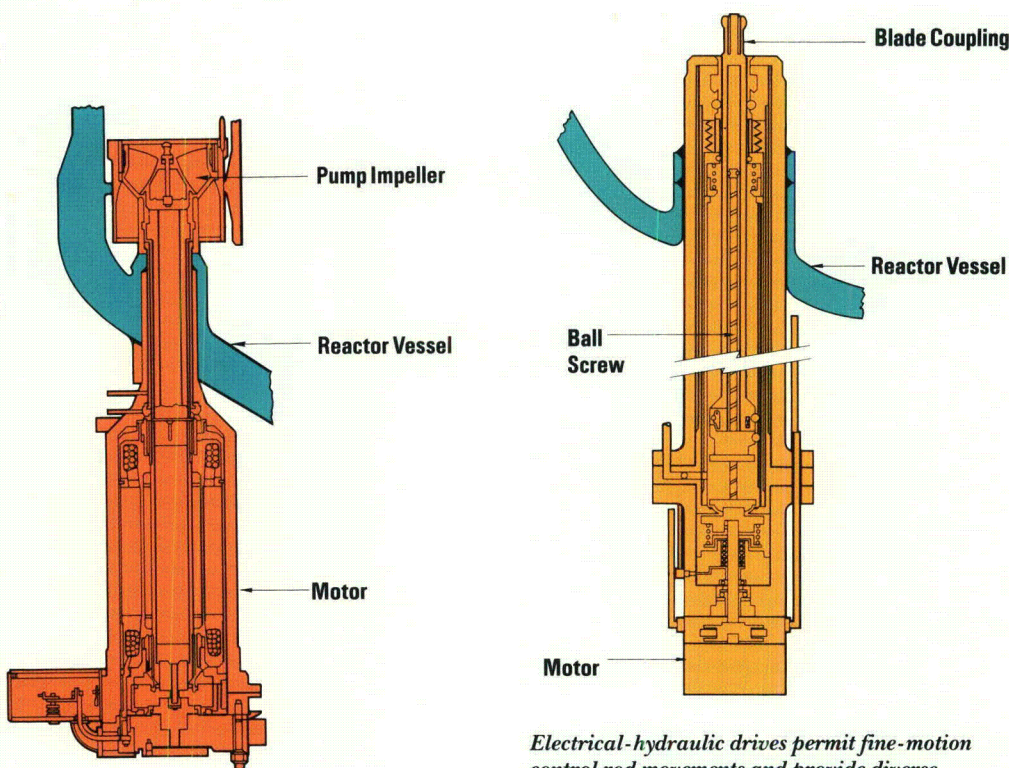
at Three Mile Island, incorporates all relevant design improvements resulting from the lessons learned from that event.

The ABWR program reached an important milestone in 1987 when the Tokyo Electric Power Company selected two ABWR units for its Kashiwazaki-Kariwa Nuclear Power Station. Commercial operation of the first plant will take place in 1996 and the second in 1998. A joint venture involving GE, Hitachi and Toshiba is supplying the units. GE's scope of supply encompasses the reactor systems, fuel and turbine-generators.

Another milestone, certification of the ABWR design as a pre-approved U.S. standard BWR plant, is on target for 1991 completion.

Simplification—and the ability to take advantage of 30 years of international BWR experience—play a key role in the ABWR development program. For example, the ABWR makes reactor operation and maintenance easier by using internal circulation pumps, in place of the external pumps of most operating plants. This eliminates piping, decreases construction time and reduces in-service inspections.

Internal circulation pumps also enhance safety by eliminating large reactor vessel nozzles and piping below the top of the core. As a result, the fuel remains covered with water even in the case of a postulated, loss-of-coolant accident.



*Elimination of external recirculation piping reduces weld requirements by more than 50 percent over current BWRs.*

*Electrical-hydraulic drives permit fine-motion control rod movements and provide diverse shutdown capability.*



# ABWR: The benefits of standardization

**GE** welcomes the initiative taken by the NRC in adopting regulations (10 CFR 52) to streamline the licensing of new, standardized nuclear power plants. The new NRC regulations create a licensing framework that will enable the benefits of design standardization to be realized in the U.S. The ABWR, based on such standardization, is only two years away from certification.

The entire ABWR plant—including the nuclear island, turbine island and radwaste facility—is now being reviewed as a preapproved U.S. standard BWR under the U.S. Department of Energy's ALWR Program. When completed in 1991, the ABWR will be the first such standard U.S. nuclear design to achieve certification.

With certification, the ABWR can be constructed on a family of sites—as defined by its site envelope—without further review of the design. As a result, expensive 10- to 15-year construction cycles can be replaced by five-year construction programs, as planned for Japan's first ABWRs.

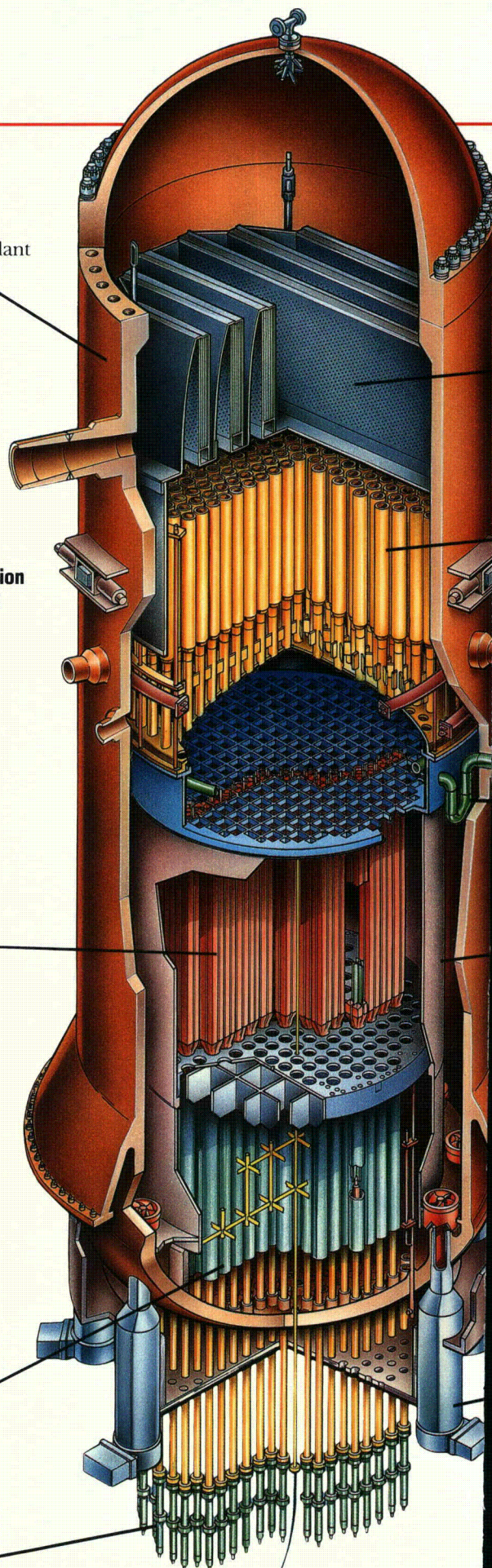
**Reactor vessel**—No large coolant nozzles below top of core

**Advanced pressure suppression containment**—Permits rapid vessel depressurization

**Advanced core and fuel**—Maximizes performance and fuel economy

**Control rod guide tubes**

**Fine-motion control rod drives**—Permit improved drive control and shutdown capability





*"The payoff from the NRC's April 1989 rulemaking on one-step licensing is more immediate than many people realize. The ABWR design is on schedule to receive the NRC's first standard plant certification in 1991. Using that design on a preapproved site will mean a dramatic, near-term construction cycle improvement for a utility applicant."*

—Bertram Wolfe  
Vice President and General Manager  
GE Nuclear Energy

*"Many utilities in the United States have grid sizes compatible with baseload units of 600 MWe or less. Combined with uncertain load growth, this scenario points the way to small, passive advanced light water reactors."*

—John Taylor  
Vice President  
Electric Power Research  
Institute

**F**eaturing less than half the electrical output of the ABWR, an SBWR plant will extend the favorable economics of nuclear power to smaller electrical ratings.

The SBWR takes full advantage of its smaller size by using gravity and natural circulation of the coolant to mitigate potential accidents. In the event of an emergency, the reactor shuts itself down and cools itself without the need for operator intervention. SBWR safety features also avoid reliance on external pumps or power supplies.

#### ABWR Technical Data Summary

##### Plant output

Net electrical output	1356 MWe
Gross thermal power	3926 MWt
Plant cycle	Direct
Vessel dome pressure	73.1 kg/cm <sup>2</sup>
Main steam flow	7640 tons/hour
Turbine	TC6F-52 inches
Reheat stages	Two

##### Nuclear boiler

Reactor vessel	
Inner diameter	7.1 m
Height	21.0 m
Primary coolant circulation	
Recirculation system	Internal pumps
Recirculation flow	52,200 tons/hour

##### Core and fuel

Active fuel length	3.81 m
Equivalent core diameter	5.14 m
Power density	50.5 kw/l
Number of assemblies	872
Fuel material	UO <sub>2</sub>
Cladding material	Zircaloy 2
Fuel lattice type	8x8 barrier

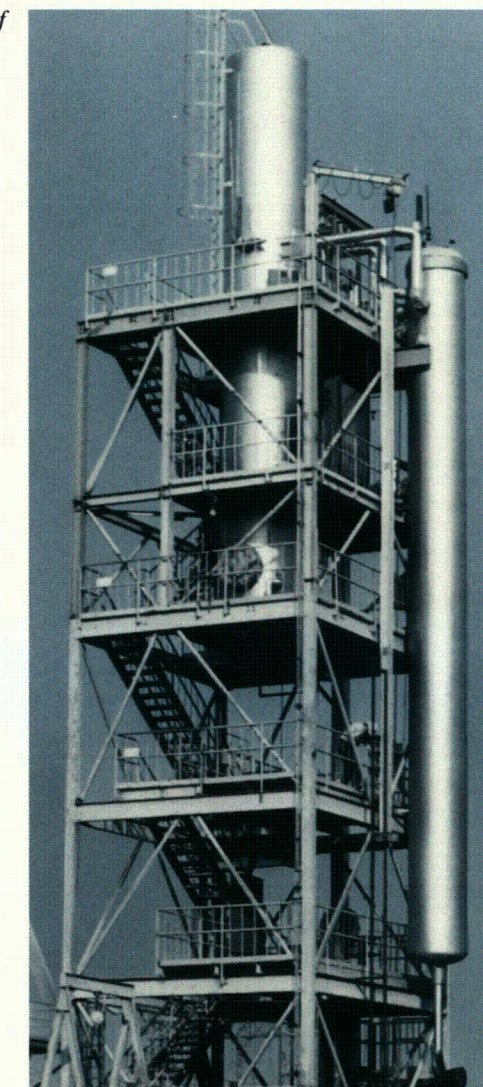
##### Reactivity control

Number of control rods	205
Neutron absorber	B <sub>4</sub> C
Control rod form	Cruciform
Control rod drive	Electro-hydraulic, fine-motion
Other control	Burnable poison (Gd <sub>2</sub> O <sub>3</sub> )

##### Containment

Type	Pressure suppression
Configuration	Cylindrical reinforced concrete

Full-scale (vertical) testing of the gravity-driven cooling system has been successfully completed.





*"We think that the standardization and certification process is the future of nuclear energy in our country."*

—Lando Zech  
Chairman  
U.S. Nuclear Regulatory Commission

Steam dryers

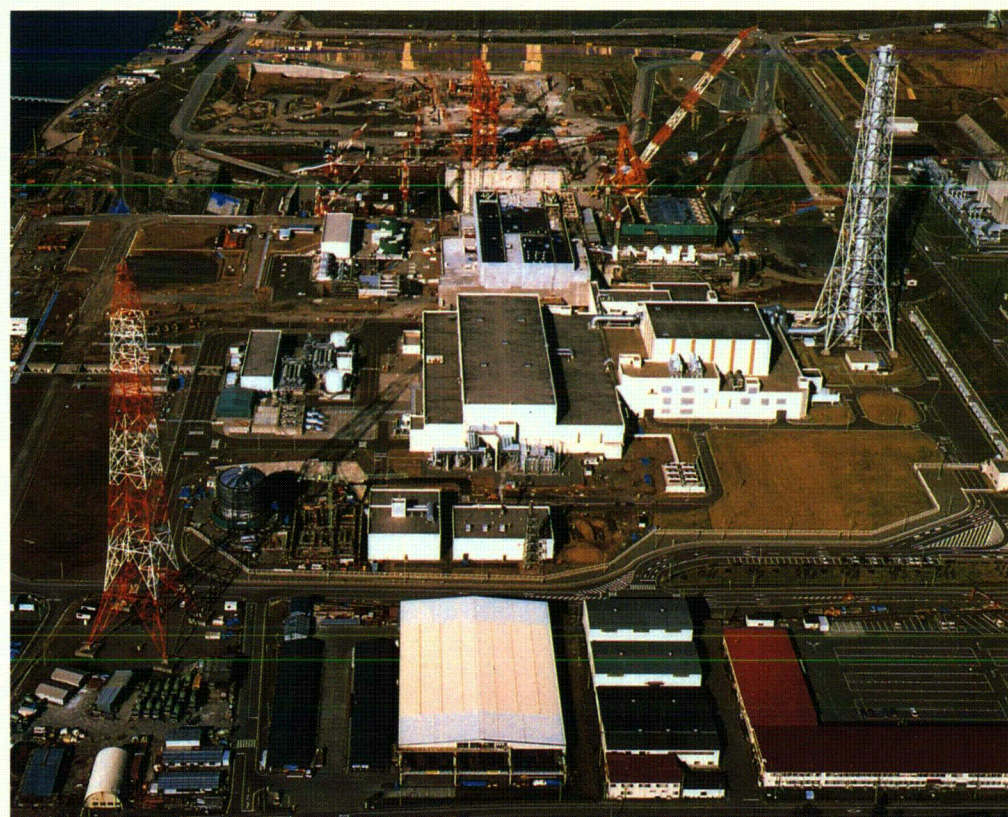
Steam separators

ECCS systems—Achieve triple-redundant core protection

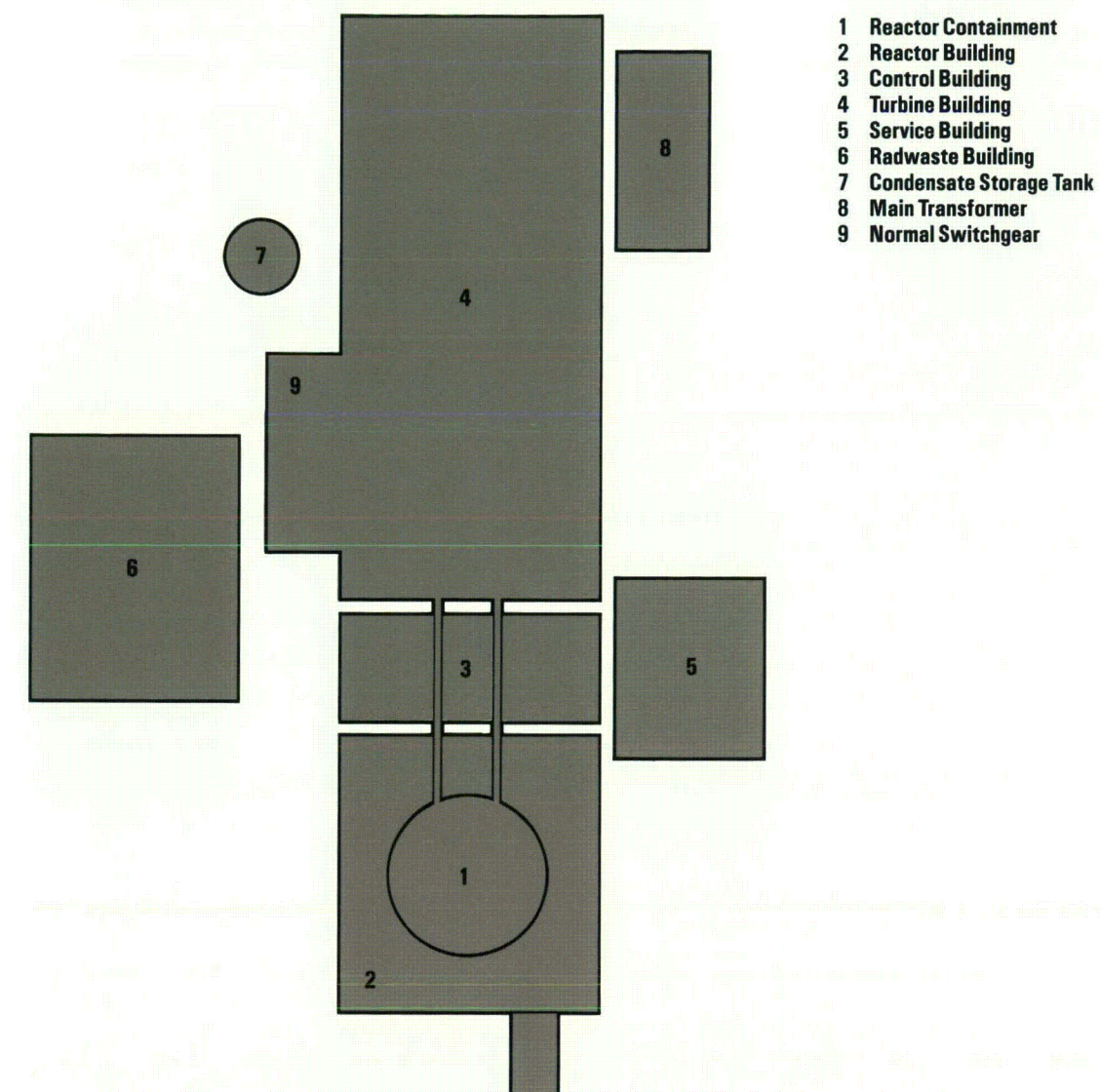
Core shroud

Solid-state, digital control systems—Improve reliability and economics

Internal recirculation pumps—Eliminate external recirculation piping



The ABWR has been selected by TEPCO, the world's largest private utility, for construction at a seven-unit site as the next generation, standard BWR in Japan.



The ABWR certification application encompasses all significant plant structures and systems.

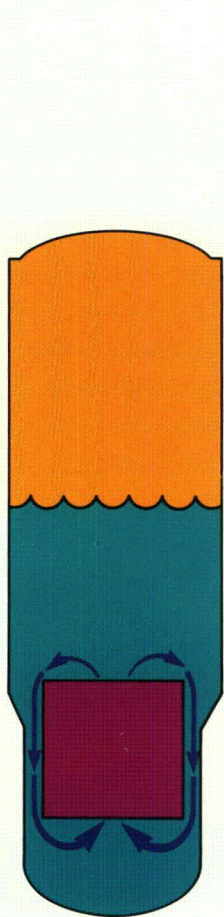


# SBWR: Passive safety and favorable economics in smaller output ratings

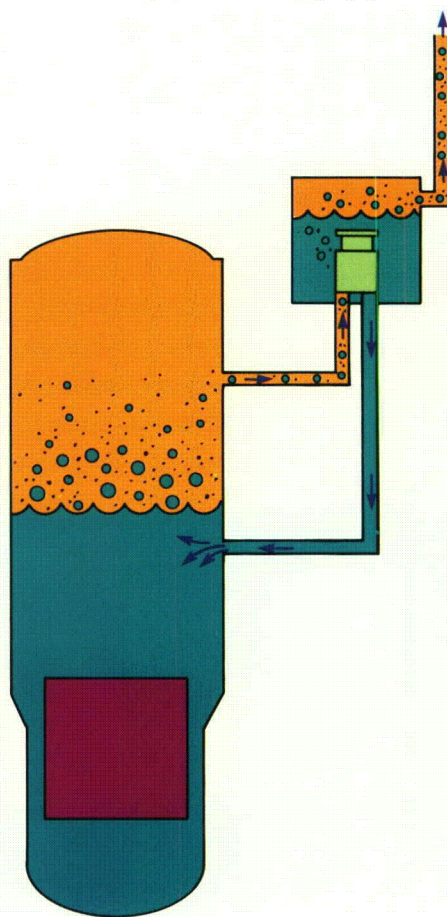
Like most GE boiling water reactors, the SBWR utilizes a pressure suppression containment to absorb vessel energy releases. In an emergency, the SBWR vessel is depressurized, and cooling water flows by gravity from an elevated pool into the reactor vessel. No operator action is needed to activate this automatic safeguard.

Significant design features incorporated in the ABWR, such as fine-motion control rod drives and digital controls, have been carried over to the SBWR.

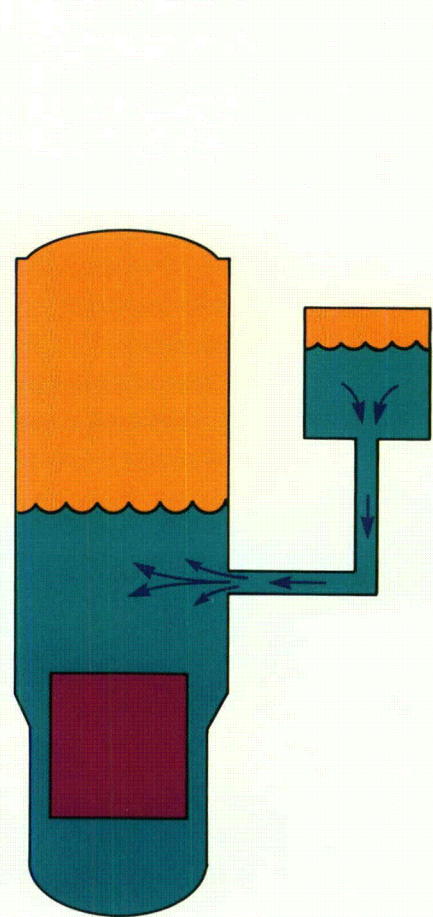
A passive containment cooling system uses natural convection to provide long-term cooling capability.



*SBWR natural circulation maintains core heat transfer.*

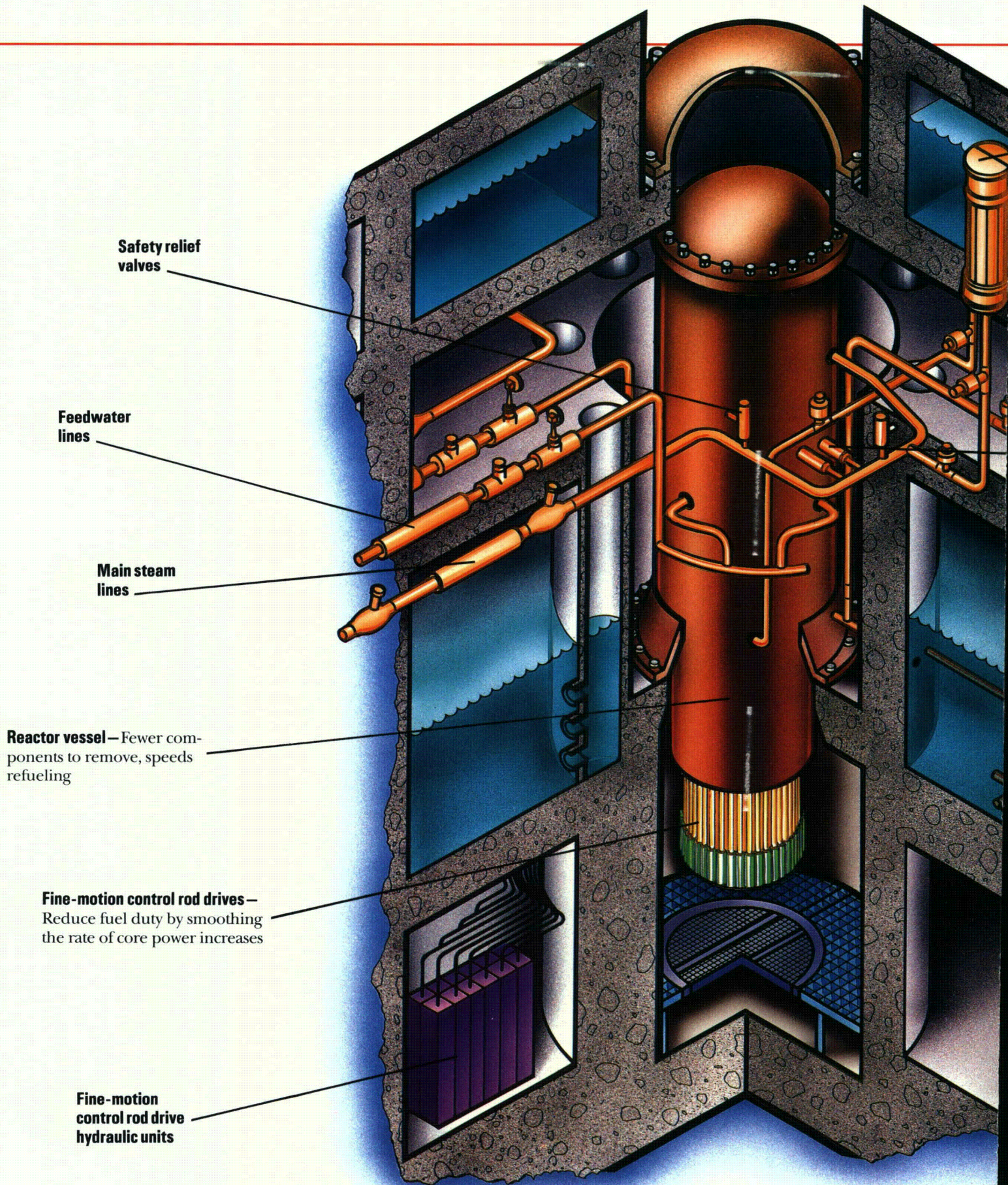


*SBWR isolation condenser for passive, long-term heat removal.*



*SBWR gravity-driven emergency core cooling system.*



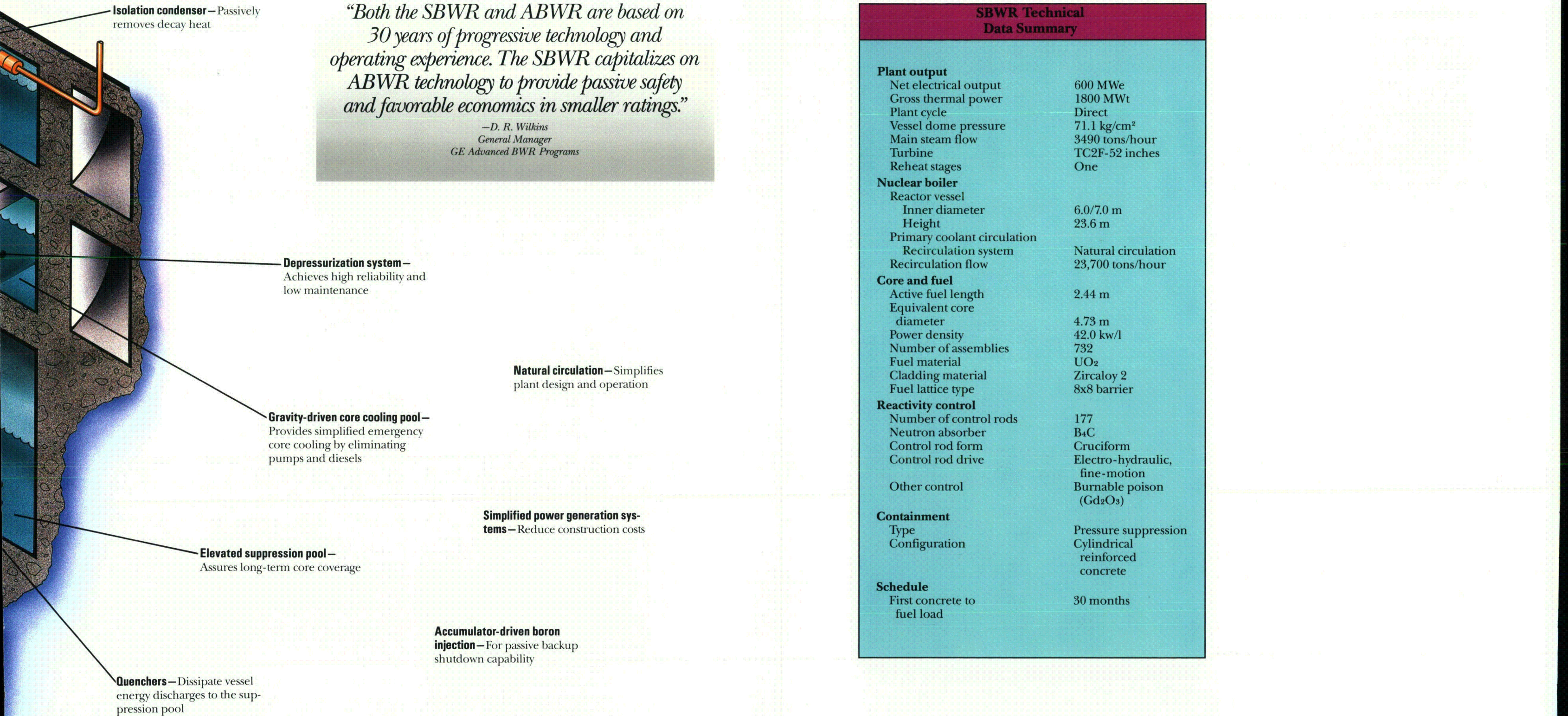




# SBWR's simplified design enhances operation and maintenance

*"Both the SBWR and ABWR are based on 30 years of progressive technology and operating experience. The SBWR capitalizes on ABWR technology to provide passive safety and favorable economics in smaller ratings."*

—D. R. Wilkins  
General Manager  
GE Advanced BWR Programs



**Isolation condenser**—Passively removes decay heat

**Depressurization system**—Achieves high reliability and low maintenance

**Gravity-driven core cooling pool**—Provides simplified emergency core cooling by eliminating pumps and diesels

**Elevated suppression pool**—Assures long-term core coverage

**Quenchers**—Dissipate vessel energy discharges to the suppression pool

**Natural circulation**—Simplifies plant design and operation

**Simplified power generation systems**—Reduce construction costs

**Accumulator-driven boron injection**—For passive backup shutdown capability

## SBWR Technical Data Summary

<b>Plant output</b>	
Net electrical output	600 MWe
Gross thermal power	1800 MWt
Plant cycle	Direct
Vessel dome pressure	71.1 kg/cm <sup>2</sup>
Main steam flow	3490 tons/hour
Turbine	TC2F-52 inches
Reheat stages	One
<b>Nuclear boiler</b>	
Reactor vessel	
Inner diameter	6.0/7.0 m
Height	23.6 m
Primary coolant circulation	
Recirculation system	Natural circulation
Recirculation flow	23,700 tons/hour
<b>Core and fuel</b>	
Active fuel length	2.44 m
Equivalent core diameter	4.73 m
Power density	42.0 kw/l
Number of assemblies	732
Fuel material	UO <sub>2</sub>
Cladding material	Zircaloy 2
Fuel lattice type	8x8 barrier
<b>Reactivity control</b>	
Number of control rods	177
Neutron absorber	B <sub>4</sub> C
Control rod form	Cruciform
Control rod drive	Electro-hydraulic, fine-motion
Other control	Burnable poison (Gd <sub>2</sub> O <sub>3</sub> )
<b>Containment</b>	
Type	Pressure suppression
Configuration	Cylindrical reinforced concrete
<b>Schedule</b>	
First concrete to fuel load	30 months



# SBWR improves cost-effectiveness through reduced capital outlays

*"(An advanced reactor) must provide very high protection of the utility investment in terms of predictable construction costs and schedules, assured licensability, predictable operating and maintenance costs...."*

—Sherwood Smith  
Chairman/President  
Carolina Power & Light

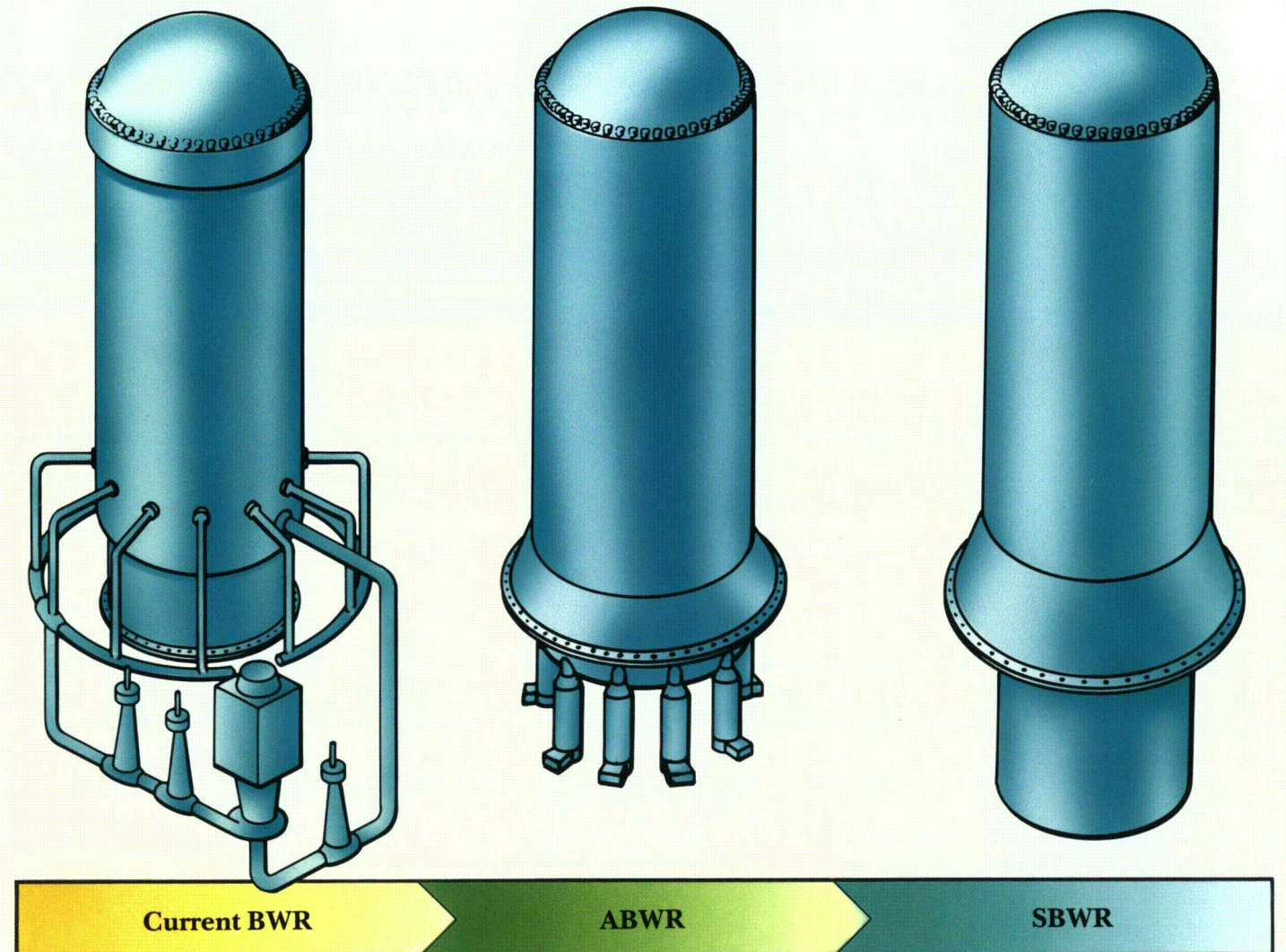
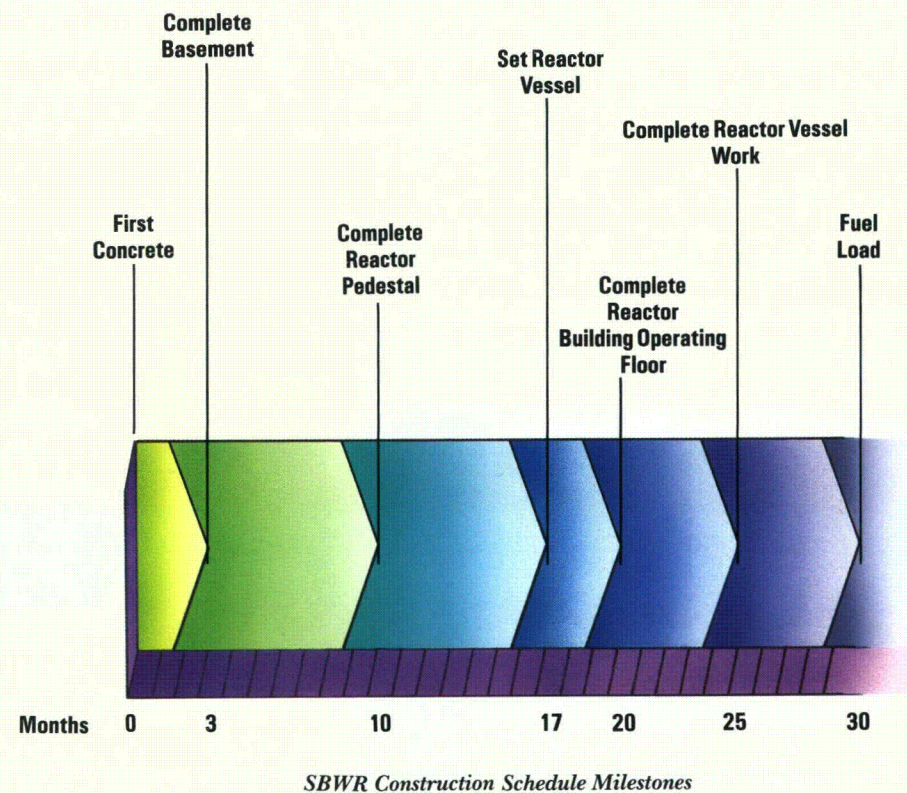
**M**ost reactor systems offered today have a capacity of 900 to 1200 MWe. In contrast, the SBWR has an output of 600 MWe. This smaller capacity, coupled with its simplified design, shortens construction time.

The simpler design incorporates more factory fabricated components

for reduced costs, improved maintenance and enhanced quality control. Modular components also contribute to shorter construction schedules.

Much of the cost associated with current reactors is the result of long construction periods which tie up a utility's capital and impose excessive carrying charges. Given a certified SBWR design, GE anticipates a 30-month construction period from first concrete to fuel loading.

To achieve a predictable licensing process, GE plans to submit the SBWR for standard plant certification by the NRC. Participation in a DOE program for detailed design and NRC certification is expected to yield a pre-licensed, standardized, investor-ready SBWR design by 1995.



Current BWR	ABWR	SBWR
<ul style="list-style-type: none"> <li>900–1200 MWe</li> <li>External, forced circulation</li> <li>Nearly 100 plants operating worldwide</li> </ul>	<ul style="list-style-type: none"> <li>1356 MWe</li> <li>Internal, forced circulation</li> <li>World-class design by international team</li> <li>Selected as Japan's next generation of standard BWRs</li> <li>U.S. NRC certification program in progress                             <ul style="list-style-type: none"> <li>First certified U.S. standard plant</li> <li>Cooperative DOE/EPRI/GE effort</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>600 MWe</li> <li>Natural circulation</li> <li>Focus on simplification and automatic safety</li> <li>Builds on BWR and ABWR technology bases</li> <li>Design and development in progress                             <ul style="list-style-type: none"> <li>Cooperative DOE/EPRI/GE effort</li> <li>International support</li> <li>Testing under way</li> </ul> </li> <li>U.S. licensing certification targeted for 1995</li> </ul>



# The BWR: A study in disciplined evolution

*"Thirty years of BWR evolution have resulted in two new reactor designs—the ABWR and the SBWR—that incorporate the best of current technology with simplified designs and reduced construction, operation and maintenance costs."*

—Bertram Wolfe  
Vice President and  
General Manager  
GE Nuclear Energy

**T**he ABWR and SBWR are based on more than 30 years of boiling water reactor experience. GE designed the first licensed U.S. nuclear plant—a BWR—which began operation in 1957. GE pursued the BWR design because the simplicity of its direct steam cycle eliminates the need for intermediate steam generators.

During the succeeding 30 years, the BWR has evolved through several

design simplification stages. With each evolutionary change, major components—proven unnecessary to the steam generation cycle—were eliminated to simplify the BWR and enhance reliability.

GE BWRs enjoy worldwide acceptance. Shortly after their introduction in the U.S., GE BWRs became the first commercial light water reactors ever ordered in Japan, Mexico, the Netherlands, India, Taiwan and West Germany. More than half the current and planned nuclear power capacity in Japan, Switzerland, Mexico and Taiwan is committed to GE-type BWRs.

In total, more than 100 BWRs, supplied by GE and its technical associates, are now operating or under construction in 11 countries.



# Meeting U.S. energy needs of the 1990s and beyond

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*“America gave birth to nuclear technology, and as we approach the 21st century, this nation can lead the world into a new era of safe, reliable, economical, and environmentally clean nuclear power... Through the efforts of our commercial nuclear power industry, our national energy security is strengthened and environmentally harmful emissions are reduced... Now is the time for America’s nuclear industry to take its rightful place in helping to meet the nation’s energy needs for the next decade and the next century.”*

*—George Bush  
President of the United States  
May 9, 1989*







***GE Nuclear Energy***

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