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FUNDAMENTAL PRINCIPLES OF SAFE NUCLEAR DEVELOPMENT

INTRODUCTION

I am very pleased to be here today to share with you some perspectives on nuclear energy. Asia is one of the fastest-growing markets for energy and will increasingly determine the shape and size of world energy demand. Energy demand in many Asian countries is expected to triple over the next 30 years, fueling a worldwide increase of energy consumption of almost 100%. By 2010, the share of total energy consumption accounted for by developing countries will have climbed from 27% to 40%, while the share of rich countries will have fallen below 50% for the first time in the industrial era. Over the next 25 years, more electrical capacity is expected to be built than was built during the previous century.

Not only is the world's overall energy production increasing at a tremendous rate, but nuclear power's share is also expected to edge up. Given the rapid pace of economic and energy development in this part of the globe, a large portion of the world's nuclear development will be in Asia, possibly even here in Indonesia.

Per capita energy consumption is presently low in the region but demand is strong and growing. Generating capacity in Indonesia has doubled in the last decade, and would have to more than double once again in order to catch up to a projected 15% annual increase in demand by the year 2000. By 2015, it is estimated that your nation will need 35 Gwe of additional capacity, equivalent to the power supplied by 40 large power plants.

These demand projections are matched by parallel gaps in supply. Several Asian countries depend heavily on imported fuel. Oil supply problems in the 1970's led Japan, South Korea, and

Taiwan to develop well-planned nuclear power programs to ensure the long-term availability of electricity. Based on growing domestic demand, even Indonesia could become a net oil importer by the end of the decade.

THE U.S. NUCLEAR PROGRAM

Compare the rapidly changing environment in Asia with the stable situation in the U.S. Nuclear power now generates about 22% of our domestic electricity -- more than double the contribution from nuclear power in 1975. The U.S. produces more nuclear-generated electricity than anyone else in the world -- we generate almost one-third of the world's total. And with 2,000 reactor-years of experience, the U.S. has more nuclear experience than any other country. New baseload plant construction -- both nuclear and non-nuclear -- is relatively quiet in the U.S. while new construction in other parts of the world is quite active, precisely because we have already undergone this growth within the past few decades and do not yet have an increased need for baseload power. And the U.S. will continue to reap the full benefits of existing nuclear plants through our plant life extension program. This should extend the life of nuclear power plants well beyond the original 40-year licensing period, while meeting rigorous safety standards. As you can see, the U.S. nuclear program is alive and well.

As for new reactors, a new streamlined licensing process is in place. The U.S. NRC has issued the design approval for one evolutionary standard reactor design -- the General Electric Advanced Boiling Water Reactor -- and is about to issue another -- for the ABB-Combustion Engineering System 80+. Our review of the even newer generation of nuclear power plants is also well along. These novel designs -- the Westinghouse AP600 and the General Electric Simplified Boiling Water Reactor -- employ passive safety features and modular construction. These features should make the reactors easier to construct and to operate, while retaining economic competitiveness. The NRC-certified designs for the passive reactors, achieved after an exhaustive analytic and experimental review process, should be available later this decade, well in time for programs such as Indonesia's which are considering using these designs.

At this point I'd like to make it clear the U.S. Nuclear Regulatory Commission (NRC) has no vested interest in whether Indonesia decides to develop nuclear power. The right mix of energy sources for any nation depends on many factors unique to that nation. Since Indonesia is seriously considering nuclear power, however, I'd like to share with you the fundamental principles that need to be followed if nuclear power is to be developed safely.

Nuclear safety is like a three-legged chair. If all three legs hold up, the chair will be very stable. But if one leg buckles or wobbles, the chair will tip over.

The first leg is technical safety, which is the usual focus of safety and regulatory programs. Technical safety is important, but it is only one of the three legs.

The second leg is economics -- a nuclear program must be well-funded; profitable enough to permit continued heavy investment, maintenance, and training; and make good business sense. An uneconomic program will eventually try to cut costs by compromising on safety.

The third leg is organization and management -- training, staffing, safety culture, standardization, responsible leadership, realistic goals.

You will note that I have not yet discussed safety regulation -- these three legs are primarily the responsibility of the national planners; of the energy, technology, and finance ministries; and of the utility. But the regulator does play a critical role in keeping the promoters and operators focused on safety. With specific regard to the regulatory dimension, four elements are especially important in establishing and maintaining an adequate nuclear safety culture.

<u>First</u>, every nuclear nation must provide a firm legal foundation for a strong and independent regulatory authority to monitor and enforce high levels of safety. Where regulators have not traditionally had the independence, or political authority, to carry out their job effectively when there is no effective oversight body with the power to close down nuclear power plants for safety violations, there is a tendency to cut corners to produce needed power as cheaply as possible.

<u>Second</u>, no amount of regulatory authority is going to be effective if the regulator does not have the necessary resources at its disposal. This means a well-trained and adequately paid staff to perform on-site inspections, review plants at all stages from design to decommissioning, and analyze errors to improve operations in the future. It also means a confirmatory research capability.

<u>Third</u>, both the industry and the regulators must apply rigorous nuclear standards which cover all aspects of the nuclear fuel cycle. One such set of principles has been developed for the International Nuclear Safety Convention, which is expected to be signed in September.

I also think the regulator should have the authority to turn these rigorous standards into the mandatory regulations that all operators must follow.

Fourth, by national law or international commitment, a state must put into place legal and financial protection arrangements which would provide adequate compensation for damage in the event of a nuclear accident, while setting appropriate limits on third party liability. Such protection holds both the nation and the nuclear power plant operators accountable for protecting the public health and safety, while assuring the public every right to redress any injury it might suffer as a result of negligence or improper operation.

Less obvious but also important, the regulator should have access to an independent, regulatory research program, to support an investigation of risks, accidents, siting, and such everyday items as corrosion, training effectiveness, or vulnerability to fire.

Where these principles have been adhered to, a culture of safety has permeated both nuclear operations and management, leading to a successful nuclear industry. Where these principles have *not* been followed, the goal of electricity production has frequently led the industry to override safety objectives when the two came into conflict.

NUCLEAR PLANT SAFETY

I have already spoken at some length about nuclear safety and the safety culture, without discussing what safety consists of at a nuclear power plant -- in other words, what exactly are we trying to prevent?

In a nuclear power plant a chain reaction takes place in the core -- the radioactive fissile fuel which is kept covered with a coolant fluid. In most reactors the coolant is ordinary, or "light", water maintained at high temperature under great pressure. The chain reaction is the spontaneous emission of neutrons from an atom of fuel, like Uranium 235, a fraction of which strike another like atom and cause more neutrons to be emitted; the controlled or stable reaction stays in equilibrium, emitting as many neutrons as it consumes. The chain reaction produces an enormous amount of heat.

The objective of the controlled chain reaction is to produce this enormously intense heat, which is carried off by the coolant to power a turbine generator which produces electricity. In carrying away this heat the coolant also keeps the fuel from melting and releasing disastrously dangerous radiation. So the same process which cools the fuel also transports the energy to be converted into electricity.

At the risk of oversimplifying, the safety function is concerned with making sure that the coolant keeps the core covered and circulates efficiently enough to carry away the heat. If the core gets too hot it will melt, releasing vast amounts of radioactivity.

An accident can be prevented or mitigated at any point in a sequence of events, by (1) preventing all challenges to the nuclear reactor that could possibly lead to core damage, (2) assuring that the chain reaction can be interrupted if a challenge occurs while the reactor is operating, (3) providing a wide range of independent, redundant, robust emergency systems which can keep the core cool and covered in the face of one or more simultaneous challenges, and (4) a containment which, even in the extreme case of core damage, could keep the radioactive release from reaching the general public.

We have the expression that an ounce of prevention is worth a pound of cure. Obviously the first line of defense in a sound safety philosophy is to prevent unnecessary challenges in the first place. Years of experience and countless analyses have shown that one of the most frequent and worrisome challenges arises from the loss of external electrical power. Therefore, a large part of the philosophy of reducing challenges is avoiding, as far as possible, the loss of off-site electricity.

However, we cannot count on avoiding challenges completely, so a defense in depth is provided. The design and the operating procedures must provide safety functions for terminating the nuclear reaction, keeping the core covered with water, and carrying heat away from the core. Furthermore, these safety features should be provided redundantly, such that no single safety system is relied on in case of a challenge. Redundancy is needed because design, manufacturing, or human error could lead to the failure of any particular safety system. I have already mentioned the essential need for continuous electrical power in reactors of current design -- electrical power is needed to keep the system operating and, in current reactors, to provide power for the major emergency safety systems. Current designs provide the back-up electricity through redundant, and expensive, on-site emergency diesel generators.

A newer design philosophy -- the so-called passive systems that Indonesia is considering -- take a different approach to dealing with the loss of off-site power. They do not rely on multiple sources of on-site electricity for emergency needs. The passive designs rely on emergency systems that reduce the pressure within the cooling system, then count on convection and gravity to circulate coolant water and to make up for any loss of coolant.

Another important contributor to risk is fire. Of course, it is best to avoid fires altogether by control of combustible materials and by good operations. But fires will occur even after rigorous prevention. Fortunately, both the probability and the effects of fires can be minimized by good plant design. In addition to the design of fire-fighting equipment, a critical step in reducing the impact of fire is the physical separation of safety equipment, so that a single fire cannot disable both the primary and the backup safety components or both sets of redundant safety equipment.

As the last barrier of defense, we provide a containment in the unlikely event that an accident should occur, even if this accident is exceedingly improbable. The containment structure and heat removal system must be designed to withstand pressure and temperature associated with a worst case loss of coolant accident; in this way the containment would keep radiation leakage to acceptable levels. Although it was weaknesses in design and operation that caused the Chernobyl accident, if the reactor had had a containment, the severe offsite consequences could have been significantly minimized or perhaps even prevented. Conversely, the Three Mile Island accident resulted in essentially no consequences to the general public, in large part because of the containment.

In short, we require systems at each stage in the sequence -- avoidance of challenge, robustness of operation, emergency safety systems, and containment -- to function with very high confidence. We do not tolerate weakness at any stage in the safety cycle, nor will we depend on overdesign at one stage to make up for weakness at another. This is what we mean by Defense in Depth.

Defense in Depth means that plant design must consider siting factors such as the potential for seismic activity and natural disasters such as hurricanes, floods, and tsunamis. The site should have access to multiple sources of offsite power from a strong electrical grid system so that the probability of a loss of electrical power is low. Access to and from the plant in case of emergency should be excellent. Siting should be in areas of relatively lower population density, just to be sure.

Design is important, construction quality is critical, but maintenance can be decisive for safety. The idea is first to prevent plant challenges from equipment failures, and second, to ensure that even if challenges do occur, highly reliable systems will be available to respond. An added benefit of high quality maintenance is that it also results in efficient economic operations.

A conservative operating philosophy is also essential to safety. The operator must not focus on short term results, such as keeping the plant operating at all costs. The view must be of a long term investment that requires short term conservative operational decisions, to ensure long term safe and efficient operations. We have seen operators focus so heavily on keeping the plant operating that it later resulted in safety challenges, extensive down times, and high costs for eventual repairs.

I'd like to stress the importance of people to nuclear safety. The plant design should make it easy for the workers, for ease of operation and for ease of maintenance. Then plant personnel must be provided with the tools needed to perform in a highly competent and safe manner. This requires high quality training and high quality support facilities. Finally, management must create an environment where people are important and where not too much reliance is placed on engineering analysis or analytical tools. We must avoid the arrogance that we have everything figured out; we must foster a questioning attitude. We have found that the safest and most efficient plants are those where people take pride in and ownership of their individual contributions to safety and efficiency. Pride and sense of ownership at all levels do not arise by accident -- they are the result of management actions to create a supportive but questioning environment.

THE ROLE OF AN INTERNATIONAL NUCLEAR SAFETY CONVENTION

Just as nuclear technology is no longer produced by self-sufficient, separate national industries, nuclear safety also is no longer simply a national concern. Therefore, in addition to strong national regulation, the NRC has supported placing the principal elements of nuclear safety regulation into the draft International Nuclear Safety Convention, to be signed next month at the General Conference of the International Atomic Energy Agency.

We believe formal agreement and wide adherence to an international nuclear safety regime will help assure a safer global environment. Safer, not solely because of guiding principles that participants are obliged to follow, but safer also because of the reporting and peer review processes implemented by the Convention. By participating fully and openly in the Convention, newly developing countries can be assured that their nuclear programs follow international guidelines. I certainly anticipate that Indonesia will be an early signer of the Convention.

The Convention requires each contracting party to "maintain a legislative and regulatory framework to govern the safety of its nuclear installations." This is to include, as I outlined earlier:

- establishing national safety requirements and regulation;
- a system of licensing nuclear installations and a prohibition on operating a nuclear installation without a license;
- a system of regulatory inspection and assessment to make sure licensees are in compliance with applicable regulations; and,
- enforcement of these regulations, supported by sanctions that could lead to suspension, modification or revocation of the operating license.

Each party to the Convention is required to establish or designate a non-funded, strong, independent regulatory body. Moreover, the functions of this regulatory body must be effectively separated from those of any other national "body or organization concerned with the promotion or utilization of nuclear energy."

Finally, there is an obligation to inform the public, since it is the public, as citizens of the land, who ultimately ensure the safety of their nuclear power program by demanding a strong and independent regulatory program.

Another important activity relates to the Nuclear Non-Proliferation Treaty. I hope Indonesia will join the U.S. in supporting the indefinite extension of the Treaty in 1995.

How does this all affect Indonesia? Indonesia is blessed with abundant supplies of natural gas, coal, and geothermal energy. Nevertheless, the extraordinary demand for electric energy, and various economic and environmental concerns, are causing Indonesia to consider nuclear energy seriously. One factor that any country contemplating nuclear energy must consider is the investment needed before ever building its first nuclear power plant. A nation must have developed a sufficient number of well-trained nuclear personnel, and must have a strong legal basis and regulatory infrastructure to allow effective regulation of the power plants. I am pleased to report that Indonesia has been taking the right steps over the course of several years to develop a firm foundation for nuclear power.

Indonesia has announced that, if it does go forward with nuclear power, it will start small, with two 600 Mwe nuclear power plants, and grow as it learns from experience -- just as it did with its aircraft and shipbuilding industries. And since any decision on nuclear power will be made at the highest levels of government, it will have the full attention and support of the President and key cabinet officers with oversight responsibility for the program. This type of commitment will help ensure that Indonesia's nuclear program, if it moves forward, will have the necessary budgetary and manpower resources required for success.

Indonesia has recognized the critical need for -- and taken steps to establish at this early stage -- a powerful independent regulatory authority. This authority will have an initial staff of about 100 to carry out its safety functions -- development of regulations, assessment, licensing, and inspection. Its first task should be the characterization of the proposed reactor site. Indonesia is addressing the need for specialized training in areas such as regulation, safety technology, nuclear plant management and operation, project engineering, and nuclear energy planning for key individuals who will form the new Agency for Nuclear Regulation. As preparatory steps to reach its goals, and as I will discuss in a few minutes, a major source of training in nuclear regulation is the U.S.-Indonesian Safety Program. Indonesia has also sent several engineers to Westinghouse, General Electric, and the Nuclear Plant Institute at Karlsruhe to obtain first-hand experience in the nuclear industry. And Indonesia has established an excellent national research capability at the Science, Research, and Technology Center in Serpong -- a capability which can be directed into confirmatory safety assessment when necessary to support a nuclear power program.

In addition to establishing a regulatory authority and developing technical expertise, Indonesia is reaching out to the international nuclear community, which has a wealth of nuclear power experience and safety information to share. The International Atomic Energy Agency (IAEA) sponsored a nuclear power feasibility study in the 1980's and a nuclear power plant financing seminar in 1990. As a follow up, Indonesia has contracted for another, more complete feasibility study, which New Japan Engineering Consultants (NEWJEC) is conducting. Begun in 1991, this study is to provide an objective evaluation of the economic, technical, and siting aspects of a nuclear power program in Indonesia. The technical and economic portions of the NEWJEC study was completed late last fall; the siting portion is expected in early 1996. Indonesia has recently decided to expand this feasibility analysis within independent review. Indonesia's final decision on nuclear power will await the conclusion of these studies and careful consideration by the Government which, I have no doubt, will also provide the public with opportunities to be heard.

U.S. REGULATORY COOPERATION WITH INDONESIA

The U.S. NRC has long provided its support to other governments seeking to set up or improve nuclear regulatory programs and has established nearly thirty regulatory exchange arrangements.

NRC's cooperation with Indonesia has grown out of ten years of annual contacts by delegations on both sides, primarily under the auspices of the U.S.-Indonesia Nuclear Joint Steering Committee. We formalized this cooperation in October 1992, when we signed an information exchange and cooperation arrangement with BATAN, the Indonesian National Atomic Energy Agency. We have made a commitment to help Indonesia train a core group of nuclear safety personnel and now host four BATAN staff members who are learning the philosophy and practice of basic regulation in the U.S. They will carry their experience back to Indonesia next year and share what they have learned, while we begin anew with four more assignees on the NRC staff.

IN CONCLUSION

As Indonesia stands on the brink of unprecedented growth and prosperity, a factor directly impacting Indonesia's ability to sustain this growth will be the availability of safe, reliable and economical electric energy. I wish to emphasize again that the decision on whether to develop nuclear energy as part of an overall energy plan belongs to Indonesia alone. It is a decision that will have a profound effect on Indonesia's future. As demonstrated in the U.S., Japan, Western Europe, and elsewhere, it is possible to develop nuclear power safely if one gives safety the priority that it deserves and if nuclear power fills a real economic need. Where the fundamental principles of safe nuclear power have been adhered to, nuclear power has safely met much of the world's energy needs. Indonesia has been on the edge of nuclear power development for several years. It has made tremendous progress in building the infrastructure so essential to the safety and successful development of nuclear power. Indonesia has clearly demonstrated its commitment to these safety principles and a willingness to "do its homework" in developing a solid foundation for safe nuclear power.