TESTIMONY

BEFORE THE

SUBCOMMITTEE ON NUCLEAR REGULATION

OF THE

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

BY
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Senator Hart, members of the Subcommittee on Nuclear Regulation of the Senate Committee on Environment and Public Works, my name is Herman Dieckamp. I am president of General Public Utilities and a director of each of the three operating subsidiaries, Metropolitan Edison Company, Jersey Central Power and Light Company, and Pennsylvania Electric Company, that are the owners of the Three Mile Island Nuclear Plant. We are here to present our preliminary understanding of a number of the aspects of the accident at Three Mile Island. Since the accident, several hundred GPU and Met-Ed employees as well as a great number from the nuclear industry and various government agencies have been and are currently working around the clock to ensure the continued health and safety of the public. We are all extremely greatful that the radiation exposure levels to the public have been low. We are, however, in no way complacent about the result of the accident.

The accident at Three Mile Island on March 28, 1979 has had a profound and shocking impact on the residents of central Pennsylvania, Met-Ed and GPU, our customers and employees, and on the future of nuclear energy. While nuclear power plant systems and procedures have been designed to accommodate extreme malfunctions of both equipment and personnel, the reality of this accident has had a far greater impact than we could have ever projected.

We pledge our sincere support and cooperation in the efforts of this committee to make known and to assess the full meaning of this accident. At the outset we would like to emphasize that we do not in any way wish to minimize the significance of this accident and we seek no excuse from our responsibilities as plant owners and operators. We strongly believe that it is important to understand the factors which contributed to this accident and to the ability of our Company, government agencies and the affected population to cope with it. If this accident is viewed simply as a matter of management or operator failure, the full significance of this experience will be lost. The accident was a result of a complex combination of equipment malfunctions and human factors. The accident departed from the accepted design basis for current nuclear plants. The response of all organizations was influenced by the fact that it was the first accident of this magnitude in the history of the U.S. commercial nuclear power program.

It is our hope that this testimony and these hearings can contribute to an understanding of this accident and the many complex factors that led to it.

In our testimony today we will discuss the following specific topics:

1. Accident Causes
2. Plant Status - Present and Future
3. Development of Understanding
4. Radioactive Material Releases
5. Emergency Plan
6. Organizational Response
7. Company - NRC Interface
8. Long Term Outlook

ACCIDENT CAUSES

We do not propose today to present a detailed description or sequence of events for the accident. We are in general agreement with the NRC testimony on this subject as previously presented to the committee.

We would like to focus this portion of the testimony on our initial impression of the primary causes of the accident.

While Met-Ed and GPU have not completed a detailed reconstruction of the accident or attempted to verify the relative importance of the many ingredients by means of calculational models, the following appear to be the major causes of the severity of this accident.

a) Shortly after the turbine and reactor trip at about 4:00 a.m. on March 28, a reactor coolant system pressure relief valve opened to relieve the normal pressure excursion, but the valve failed to reclose after the pressure decreased. The operator was unaware the valve had not closed. An order for valve closure was signaled in the control room. The operator monitored temperature near the valve to indicate valve position. However, the temperature did not clearly confirm the continuing coolant flow thru the valve. The loss of reactor coolant and accompanying reactor coolant system pressure decrease continued for about two hours until the operator closed the block valve which stopped the loss of reactor coolant.

b) The operator anticipated reactor coolant system behavior and immediately began to add make-up water to the system. When system pressure decreased to 1600 psi about 2 minutes into the accident the High Pressure Injection (HPI) safety system was automatically initiated.

   Four to five minutes into the accident the operator reduced injection of water from the HPI system when pressurizer level indicated that the system was full.

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c) Operator training and experience had emphasized the retention of a steam vapor space in the pressurizer. However, following the rapid depressurization of the system, the pressurizer level indicator inferred a high level throughout the reactor coolant system. This level indication led the operators to prematurely reduce HPI flow. The operator apparently did not anticipate that continued depressurization could lead to steam void formation in hot regions of the system other than the pressurizer and that under these conditions his level or fullness indication was ambiguous and misleading.

d) Because of the presence of steam voids in the primary system, indicated flow decreased. The operator turned off the main coolant pumps in order to prevent damage to the pumps.

e) An emergency feed system, designed to provide cooling to the steam generators in case of loss of the normal feed water system, was blocked because of two closed valves. This system would have been available to provide secondary cooling. The operator discovered this condition and initiated secondary system emergency cooling by opening the closed valves 8 minutes after the start of the plant transient. The plant safety system surveillance program had called for the placing of these valves into the closed position six times during the first 3 months of 1979 for testing of the operability of the pumps or valves. The surveillance program required a verification of valve position twelve times during this period. The last test of the emergency feed system was conducted on the morning of March 26, about 42 hours before the March 28 accident.

f) Primary coolant initially vented through the pressurizer relief was pumped into the auxiliary building because the containment design did not require isolation until building pressure reached 4 psi.

The first five of the above factors led to severe undercooling of the reactor core. The fuel became extremely hot and the integrity of the fuel cladding was lost. The first indication of fuel cladding damage and fission product release came with high radiation alarms. An extensive reaction between fuel cladding and primary coolant steam liberated large quantities of hydrogen gas into the primary reactor coolant system. The resulting configuration of the reactor core is still the subject of analytical attempts to reconstruct the accident. At various times during the day of March 28 as the operators worked to reestablish control of system cooling, the core suffered additional overheating and damage. Forced cooling of the primary system was reestablished at about 8:00 p.m. on the 28th.

Performance of the plant operators has been the subject of much speculation. Their performance must be viewed in the context of:

1. Ambiguous and contradictory information in the control room relating to pressurizer level and relief valve closure.
2. The experience and training underlying the operators' emphasis on maintaining pressurizer level.
3. The operators' awareness of equipment limitations.
4. The time and opportunity to assimilate large quantities of data.

The operators on duty at the time of the accident are a qualified and competent group. They performed their functions professionally in a period of extreme stress. Our own investigation and the many other governmental investigations will ultimately attempt to determine the role of operator performance in this accident.

PLANT STATUS - CURRENT AND FUTURE

The plant is stable. The fission product decay heat being liberated in the damaged reactor core/fuel is about 3 Mw thermal (0.1% of full power). This power level is normal for this time after a reactor trip. The reactor primary coolant is being circulated by one primary coolant pump. The average temperature of the primary coolant is about 175°F. As a result of local flow restrictions associated with the physical damage to the core, the highest in-core thermocouple reading is 275°F. The heat from the reactor plus the heat input from the one operating pump (6 MW) is being rejected through one steam generator and the plant condenser.

The immediate objective of the activities at the plant is to establish a redundant heat removal path through the plant's second steam generator and an intermediate heat exchange loop without using the plant condenser. In the cold shutdown mode, the primary reactor coolant will circulate by means of natural convection because of temperature and density differences. This will transport the core heat to the plant's two steam generators for ultimate rejection through two independent secondary paths. The objective is to minimize the number of active components that must function in these circuits in order to ensure reliable heat removal.

The plant should achieve the cold shutdown mode sometime during the next 2-3 weeks. The plant's several and original emergency cooling capabilities are available to backup the basic cooling plan. One of these systems, the plant's decay heat removal system has been the subject of a high priority effort to upgrade the ability of that system to miminize releases to the environment while operating with high primary coolant radioactivity. As part of this effort, work is under way to enable the ins[illegible]lation of redundant backup modules in addition to the two that are part of the plant design.

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DEVELOPMENT OF UNDERSTANDING

The accident differed from the popular perception of common accidents because of the extended time necessary to achieve a full definition of its scope.

The accident's initiating event was a loss of feedwater flow. During the first few minutes following this event, the plant staff attempted to recover from what they thought was a normal transient. Beyond this time, the plant behavior became inceasingly abnormal. The loss of coolant via the reactor coolant system relief valve was identified and the valve was isolated around 6:20.a.m. At approximately 6:50 a.m. several radiation alarms alerted the staff to possible reactor core damage. In the time period of 5:30-7:30 a.m. the reactor core became uncovered and suffered extensive damage, including significant zirconium-water reaction. During the next 12 hours, the operators attempted a number of strategies to establish dependable core cooling. This objective was achieved about 8:00 p.m. on March 28, at which time the plant symptoms included:

a) Some local reactor coolant temperatures were above coolant saturation temperature.
b) High radiation levels existed in the reactor containment and the auxiliary buildings.

A preliminary sequence of events was being extracted from the various plant records by the afternoon of March 28. The data for the 16-hour accident period became available in summary graphical form on the morning of March 29. The probable occurrence of a zirconium - water reaction and the presence of hydrogen gas in the reactor containment building was deduced during the the evening of March 29 from containment pressure records that indicated a pressure spike during the accident. The size of the hydrogen gas bubble in the reactor coolant system was first measured from system data just after midnight March 30. The concentration of hydrogen gas in the containment building was determined from analysis of the first containment gas sample taken about 4:00 a.m. on March 31. The first quantitative data with respect to fission product release and degree of reactor fuel damage became available via analysis of a primary coolant sample taken at 5:00 p.m. on March 29. The point of this enumeration is simply to indicate the time necessary to gain insight into the scope of the accident and, in turn, to provide the basis for a meaningful assessment. In any evaluation of the timeliness of the accident assessment, it must be remembered that the plant management and staff faced immediate, continuing and first priority demands to maintain the damaged plant in a controlled and safe state.

RADIOACTIVE MATERIAL RELEASES

A release of fission products to the containment building occurred during the first forty-five minutes of the accident when water was released from the primary reactor coolant system through the pressurizer relief valve. This water was first contained within the reactor coolant drain tank in the reactor containment building. Shortly after the initiation of the accident, pressure buildup in this tank resulted in the release of coolant to the containment building floor. This coolant collected in the containment building sump and was pumped into the auxiliary building sump. The auxiliary building sump overflowed and resulted in several inches of water on the floor of the auxiliary building.

Containment isolation automatically occurs in the TMI 2 plant upon a 4 psi pressure increase in the reactor building. In the accident that occurred this pressure buildup did not exist until 5 hours into the accident and thus containment was not isolated until 9:00 a.m. Operator action turned off the containment sump pumps approximately 40 minutes into the event.

High fuel cladding temperatures produced by inadequate core cooling during the accident resulted in the breach of most of the fuel cladding in the core beginning about 90 minutes into the accident. This failure of the first level of fission product containment resulted in the release into the primary system of the gaseous fission products from the fuel-cladding gap and a fraction of the fission products normally contained within the fuel pellets.

After extensive fuel damage occurred, highly contaminated primary coolant and gases may have entered the auxiliary building through a number of routes including reactor coolant pump seal leakage, instrument sample lines, and the primary coolant make up and let-down systems. We are not currently able to ascertain in detail the importance and contribution of these possible release paths. Our analysis is now impeded by the inability to physically examine specific systems due to high radiation levels.

Continued operation of the primary reactor coolant letdown and makeup systems to remove gas from primary coolant circuit resulted in a buildup of hydrogen, iodine, and noble gases in the reactor make-up and let-down systems and in the waste gas decay tank in the auxiliary building. Steps necessary to restrict tank pressure levels, the taking of gas samples, and efforts to discharge these gases back into primary reactor containment building resulted in a series of radioactive gas releases. The largest of these occurred on Friday, March 30 at 6:40 a.m..

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The iodine releases from contaminated water in the auxiliary building and from other gaseous sources passed through iodine filters in the auxiliary building with the result that net iodine releases off site have thus far been limited. In recognition of the inventory of iodine in the auxiliary building and the deterioration of existing filters, charcoal filters have been replaced and an additional charcoal filter system is being installed in series with the existing plant filter system. This existing iodine inventory is being reduced by a factor of 2 every 8 days by radioactive decay.

NRC has calculated the highest integrated whole body dose possible to an unprotected individual continuously positioned outdoors at the plant boundary and thus totally exposed throughout the accident. This was 85 millirem and is consistent with the highest offsite dose measured by Met-Ed.

In addition to the maximum integrated whole body dose measured from the accident, the total dose to the population within 50 miles has also been evaluated. The results of this analysis indicate that the aggregate whole body dose to the population within 50 miles (about 2 million people) was about 3550 person-rems from noble gases released through April 7, 1979. NRC indicates that the total potential life time health effects associated with this whole body dose are about 2, in addition to the 300,000 cancer fatalities which would be normally expected to develop in the population of about 2,000,000 persons.

Low levels of iodine-131 have been detected in air and milk sampled near the site. To date, measurements indicate the maximum level of iodine-131 in milk to be about 40 picocuries per liter. (pico = $1x10^{-12}$). This level is below the 10CFR 20 maximum permissible concentration of 300 picocuries per liter, and is well below the levels of iodine in milk detected following the 1976 Chinese weapons test.

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Low levels of liquid releases occurred to the Susquehanna River through the industrial waste water treatment system. The available data indicate cumulative releases of about 0.01 curies to the river, well below the level of 10 curies per quarter allowed under our license. In general the releases have been below MPC except for one brief period when the data indicate the hourly release exceeded release rate limits by about 30%.

EMERGENCY PLAN

Both Three Mile Island and the Commonwealth of Pennsylvania had formal written emergency plans in place before TMI 2 received its operating license.

Under the emergency plans, there is a clear division of responsibility between Met-Ed and the state authorities. In terms of the division of functions, it is Metropolitan Edison's duty to make an initial assessment of the accident, to do whatever it can to terminate or investigate the event, to read the plant instruments and monitoring devices which give an indication of the level of releases from the plant, to read the instruments telling wind direction and speed, to dispatch teams of technical personnel to areas outside the plant with handcarried monitoring devices to record measurements in the path of the plume and report these back to the plant emergency control center by radio and to keep the Bureau of Radiological Protection informed on all these matters. Plant personnel have been trained in these functions and perform periodic drills for various simulated accidents.

So far as state agencies are concerned, it is the responsibility of the Bureau of Radiological Protection to make the decision as to what measures of protection, including evacuation, should be undertaken. If evacuation is called for, it is the responsibility of the state and local emergency centers to carry out the evacuation.

Emergencies which could have consequences off site are classified as either a Site Emergency of a General Emergency. Site emergencies are those which have a potential for off-site consequences and General Emergencies are those with definite off-site consequences. The emergency plans specify precisely the conditions in the plant which trigger the declaration of a Site of a General Emergency and which initiate implementation of notification and intensified radiological monitoring procedures. Both levels of emergencies require notification of off-site authorities.

In the initial stages of the accident at TMI 2, the plant operators thought they were experiencing a normal plant transient involving loss of feedwater, which resulted in an automatic trip of the electric turbine generator and an automatic reactor trip. About a half hour after the initial reactor trip, a radiation alarm on the intermediate cooling system was received. In light of the operator's knowledge of the position of this detector in an area of generally high background radiation and its low setpoint, this was not viewed as an indicator of an emergency and it is not a criterion for declaring a Site or General Emergency. Throughout the next several hours there were no additional radiological alarms or other indications of the potential for off-site releases. At about 6:40 a.m. a radiation monitor located near primary coolant sampling lines alarmed and chemistry/health physics technicians surveying with portable monitors in areas of the plant detected radiation levels.

It was not until 6:50 a.m. almost three hours after the accident was initiated and the reactor tripped, that radiation monitoring devices in the unit alerted operators to the real potential for off-site releases. At this time, the first criterion for declaring a Site Emergency was met, when a reactor building high range gamma monitor alert alarm was received.

. In accordance with the emergency plan procedures, a Site Emergency was declared and notifications to authorities were initiated. Pennsylvania's Emergency Management Agency was notified at 7:02 a.m.; Dauphin County's Emergency Center was notified at about the same time. These organizations in turn commenced their notifications to state and local authorities. The State's Bureau of Radiological Protection (BRP) duty officer was notified at 7:04 a.m. by the State Emergency Management Agency duty officer. The BRP duty officer, thereafter, contacted the control room at Three Mile Island to gain technical knowledge about the event. A call was placed at 7:04 a.m. to NRC's regional office in King of Prussia, Pennsylvania. The answering service which received this call was alerted to the reactor trip, the possibility of primary to secondary leakage through a steam generator, to the declaration of a Site Emergency at TMI 2, and to the fact that no releases were known to have occurred at that time. Notification followed within minutes to others on the prescribed list of organizations to be notified. About 7:24 a.m., the reactor building high range gamma monitor high alarm was received, which by the plan triggered escalation of the emergency classification to the level of a General Emergency. Notifications of this new change in status were initiated. During the period from 7:30 to 8:30 a.m. the emergency plans were fully initiated. Communications both on site and off site were established. Radiation monitoring teams were dispatched off site to detect and verify releases.

Throughout the day of March 28, 1979, on-site and off-site radiological monitoring teams were providing a full flow of data to the Emergency Control Center at Three Mile Island. Constant communication existed through open lines from Unit 2's Control Room to the State's Bureau of Radiation Protection and to NRC's offices at Region I in King of Prussia. As data was received at the site from radiological monitoring teams off site, it was immediately relayed to both NRC and to the State through the open-line channels established in the emergency plan and implemented on this occasion. From shortly after 10:00 a.m., NRC had personnel in the control room itself.

From our vantage point, the Three Mile Island radiation emergency plans and procedures were effectively implemented. The decisions to declare the Site and General Emergencies were made by the individuals in charge when the specific criteria required these decisions to be made. Emergency stations were manned and off-site notifications were made and in accordance with the plan. Open lines and a flow of communications with the critical off-site agencies were established. Radiation monitoring results and plant status information was available and communicated to both NRC and to the Pennsylvania Bureau of Radiation Protection. We must expect that further review of this experience will identify opportunities for improvement.

ORGANIZATIONAL RESPONSE

The initial perception was that the plant had experienced a severe transient, there was some fuel cladding damage, but conditions were stable and the immediate need was to identify and understand the cause of the event. By approximately 7:30 a.m., Wednesday, March 28, available senior plant operations and technical support personnel were on site. By that afternoon two Met-Ed and four GPU Service Corporation personnel arrived at the TMI site to provide technical assistance to the plant staff. On Thursday morning, March 29, a seven-man team was dispatched to the site to initiate an investigation into the accident. When the team gained a first hand awareness of the condition of the plant late Thursday afternoon, they immediately turned

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their full attention to assessing plant status, providing analytical support to the continuing operating decisions that had to be made, and identifying continency plans in order to keep the plant in a safe condition. This activity was a demanding one and absorbed the approximately 80-100 personnel, about half from GPU member companies and half from other utility industry companies, brought to the site over the next few days.

The GPU vice president who is responsible for generation plant design and construction, and who previously had been the Met-Ed vice president responsible for TMI, arrived at the site early Friday morning, March 30, with plans for organizing and manning the ongoing effort. Later Friday morning when a burst of radioactive gas was released from the auxiliary building, awareness of the magnitude of the problem was sharply increased. During the next 30 hours we were in phone contact with the nuclear industry. We asked for support at the site in the form of senior experienced nuclear scientists, engineers, and technicians and found everyone eager to help. By late Saturday afternoon, March 31, about 30 people from 10 organizations arrived at the site to form the nucleus of what has been variously known as the Industry Advisory Group or the "thinktank". I met with the group early in the evening of Saturday, March 31, and asked the group to organize itself to evaluate four prime areas:

1) What problems do we face in waste management to minimize offsite exposure?
2) What is the state of the damaged core?
3) What problems exist in the then current primary cooling mode (with a bubble)?
4) What are the options available for progression toward cold shutdown?

Over the next three weeks, the Advisory Group utilized the skills and experience of about 100 nuclear specialists. Their participation has been extremely valuable and we are forever indebted to them for their unselfish dedication.

Concurrently, the Met-Ed and GPU staff began their own assessment of these topics and began to work with the B&W staff in Lynchberg, Va. and to access the capabilities of the other nuclear steam supply vendors. We were attempting to deal with current and prospective problems that bore little relationship to the design basis of the plant.

Despite GPU's seventeen years of nuclear involvement, our thirteen power reactor years of experience and a complement of over 1000 employees devoted to nuclear activities, our resources and our lack of prior experience with this kind of situation limited our own ability to completely determine the plant status, to establish a plan of action, to determine priorities and to supply management leadership.

During the first few days after the accident the priorities were identified to be:

a) Maintain the plant in a safe operating mode with emphasis on contingency plans in anticipation of component failures due to the high radiation levels and radiation inhibition to maintenance.

b) Minimize the fission product activity releases and the off-site exposures to the public. The initial problem areas included waste water management, suppression of iodine release from liquid spills, replacement of iodine filters, and filter additions.

c) Devise and implement a safe transition from the post accident cooling mode to cold shutdown with provision for backup strategies to ensure continued safe removal of the core's residual heat.

d) Reinforce the plant's emergency systems to assure safety in the cold shutdown mode with its unique demands. A critical activity has been to improve the integrity of the decay heat removal system and to enable the installation of redundant backup systems if required.

By Tuesday, April 3, the combined efforts of the Met-Ed/GPU staff, B&W, and the Industry Advisory Group resulted in a Base Plan for transitioning the reactor from its post accident status to cold shutdown. Since that time, the plan has undergone minor adjustments as a result of further independent review by the Advisory Group and NRC and as a result of the added information and experience gained by our staff as a function of time.

On Wednesday, April 4, an organizational structure for the TMI-2 recovery effort was put in place. The organization gave recognition to the continuing control of plant conditions, the need for significant engineering and analysis support, special emphasis on waste management, and leadership to the various plant modification tasks. This overall organization was placed under the direction of Mr. R. C. Arnold, Vice President-Engineering & Construction, of the GPU Service Corporation. At the same time the organization was bolstered by the infusion of a number of senior executives from Duke Power Co. and Commonwealth Edison Co. The organization was further strengthened by health physics and plant operations people from a number of utilities as well as numerous engineers from the nuclear industry. We wish to publicly express our gratitude for the outpouring of support we were given.

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COMPANY - NRC INTERFACE

The role of the NRC and the relationship between the Company and the NRC has been the source of much speculation in the press. The Company's view of the relationship is one of mutual respect and cooperation. The popular perception of the relationship may have been significantly colored by the Company's election to reserve comment on plant status and plans. The NRC spokesmen adequately covered this aspect of communication. It has been our judgment after the first few days and up to this time, that the public interest was best served by minimizing the opportunity for media emphasis of minor nuances of expression. A serious side effect of this policy has been to create the public impression that the Company was not contributing to the management of the post accident efforts. We believe that Met-Ed and GPU have effectively responded to this accident.

The management and resources made available by the Company for accident control must be evaluated in light of the unexpected and first of a kind nature of this accident. As a result of this accident all parties should be more aware of the demands of this kind of situation and better prepared to cope in terms of leadership, manpower and material resources. In retrospect, it is our impression that the Company and the NRC both experienced similar and somewhat concurrent phases in coming to grips with the situation.

The question of who is in charge has not been a critical factor. The Company has from the outset recognized the role of the NRC in this accident situation. The NRC's access to the control room provided direct and immediate access to plant status from mid-morning of March 28 on. The need for NRC approval of "off normal" actions and procedures has occurred with limited bureaucracy. The Company encouraged a reduction in the normal regulator/regulatee relationship and invited the NRC to participate directly

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in the twice daily technical and progress review meetings at the site. There were tense moments, but we must emphasize that it is the Company's view that the relationship with the NRC is constructive and effective. We have been able to close ranks so as to effectively employ our joint resources.

LONG TERM OUTLOOK

With respect to the longer term outlook for repair and return to service of TMI 2, it is too early to be able to provide even a rough schedule or cost estimate. Experience with the clean up and recovery of other reactor incidents suggests that the problem is technically manageable. It will, however, be significantly influenced by the availability of financial resources, regulatory requirements, and public acceptance. The replacement power cost alone of the normal 4-5 billion annual kilowatt hours output of TMI 2 provides to our customers an incentive for restoration in excess of $100 million/year.

While the Company cannot and does not seek to disassociate itself from the causes of the accident, we do believe that the accident involved the entire technological, and regulatory infrastructure of nuclear power. The public is protected by Price Anderson. The Company has the benefit of property insurance. Beyond these, there are significant costs associated with replacement power and a large investment that may not be used and useful for some time. If this unanticipated cost could be distributed over the 400 reactor years of commercial nuclear power to date, it would not significantly detract from the economics and value of this energy resource. However, the cost of this accident when concentrated on the 1.5 million customers and the 170,000 stockholders and the other investors in TMI 2's parent and subsidiaries is extreme. The traditional constraints of the utility regulatory process impose significant impediments to the easy discussion of the ramifications of an accident of this type and a ready resolution of the proper sharing of costs between the customers and the investors. To date the industry has underestimated the importance of diversifying this financial risk and thus spreading the cost of the development of the technology over the total beneficiaries of nuclear power. The institutions charged with the responsibility to supply a secure, abundant, and economic source of electrical energy must be able to withstand the impact of an event like the accident at TMI 2. The system must retain the ability to balance the social and economic costs of energy supply and energy availability.

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