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REASSESSMENT OF NUCLEAR ENERGY IN CALIFORNIA

A POLICY ANALYSIS OF PROPOSITION 15 AND ITS ALTERNATIVES

Legislature
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May 12, 1976

Hon. Leo T. McCarthy
Speaker of the Assembly
California Legislature
Room 3164 - State Capitol
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Dear Mr. Speaker:

Transmitted herewith is the report of your Committee on Resources, Land Use, and Energy on the issues raised by Proposition 15 based on our fifteen-day series of hearings conducted in Sacramento in the Fall of 1975. Our analysis attempts to use a broad logical framework for examining the need for a reassessment of the use of nuclear power in California and so goes beyond the specific provisions of the Nuclear Initiative. Our analysis does not advocate either a yes or a no vote on the Initiative but remains neutral to the best of our ability.

The Committee wishes to express its appreciation for your assistance and the cooperation of the Rules Committee and its Chairman, The Honorable Leon Ralph, in the conduct of this project. We believe the approach the Assembly has taken in this matter will be well-received by the citizens of this State.

Sincerely yours,

Charles Warren

CHARLES WARREN

CW:mvd

FOREWORD

This analysis, the transcripts of the 15 days of hearings on which it is based, and a summary voters guide were prepared by the Committee on Resources, Land Use, and Energy as a service to the citizens of California who face a monumental decision on nuclear power. While we believe these documents will aid those who are confused observers of the nuclear debate as it is now focused on Proposition 15 (The Nuclear Power Plants Initiative), we hope their usefulness will transcend the immediate decision to be made on June 8. In preparing these documents the committee has adopted a neutral stance. Because of the emotional pitch of the debate, this has been a stance difficult to maintain. However, we believe we have been successful.

We wish to gratefully acknowledge the contributions of the committee staff in assembling these documents and synthesizing the thoughts of committee members. Special thanks are due Emilio Varanini, Gary Simon, and Cynthia Praul for their assistance in drafting this report and organizing the hearings, and Sue Wagnon for her forebearance in typing the many versions of this analysis.

CHARLES WARREN
Chairman

REASSESSMENT OF NUCLEAR ENERGY
IN CALIFORNIA

A Policy Analysis of Proposition 15 and Its Alternatives

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CHAPTER ONE

INTRODUCTION

The Assembly Committee on Resources, Land Use, and Energy and its predecessors have been observing and debating nuclear safety issues since 1971. In June Proposition 15 will also make voters direct participants in this debate. Because of the complexity of the issue and the gravity of the decision to be made, the committee conducted 15 days of hearings primarily to provide information to the public, as an alternative to the emotionalism and sloganeering that accompanies initiative campaigns. While the complete record of these hearings is now available, the committee realizes few will have the time or the energy to absorb the entire 4,000 pages. This analysis has been produced for those who want a deeper understanding of the debate in a condensed format where both sides are presented. This report does not recommend how to vote on Proposition 15. But it does present what the committee believes to be a sound logical framework to aid in the decision. It provides some well considered reasons for either supporting or rejecting the Nuclear Initiative.

Proposition 15 does not ask the voter to decide whether nuclear power is in fact safe. It asks the voter to decide, given recent evidence and disputes in scientific ranks, if there is sufficient doubt about the claimed safety to warrant an independent reassessment of the entire U.S. nuclear power program by the State of California. The utilities in this state are

Step 3. How Does Proposition 15 Measure Up as a Reassessment Mechanism?

Much of the controversy over the Initiative stems from alleged legal and policy problems with its provisions and environmental, social, and economic side effects it may create. The voter must decide whether Proposition 15 is workable and whether any reassessment it achieves is worth the annoyance and costs it may impose.

Step 4. What Other Viable Reassessment Alternatives are There?

The state could involve itself in an independent reassessment of nuclear power in a number of ways other than through Proposition 15. The other methods may be more preferable to the voter than the Initiative but may also be less likely to occur. The voter must weigh any shortcomings perceived in the Initiative against the chances that some other mechanism would be established.

This analysis does not attempt to draw conclusions. After listening to 120 learned witnesses who could not agree on the merits of the Initiative or the safety of nuclear power it is clear that no objective conclusions can be drawn. The questions involved require value judgments, and the voter is no less equipped to make such judgments than the most brilliant Nobel laureate.

After a brief look at the future the utilities now envision for California, the analysis turns to a closer examination of the four principal questions.

CHAPTER TWO

THE EXPANDED USE OF NUCLEAR POWER IN CALIFORNIA

Nuclear power now contributes only 1380 megawatts (MW) or 4% of the generating capacity in California. There are only three operating nuclear plants now in the state: Humboldt, Rancho Seco 1 and San Onofre 1. According to the most recent plans of the utilities[1], by 1995 28 more nuclear plants would be serving California, three from Arizona if utilities encountered no delays or constraints, exclusive of the affect of reassessment. The sites of only four of these plants have actually been approved, however. The exact locations of the remainder can only be estimated. Taking into consideration seismic and population limitations established in prior AEC/NRC decisions, it is likely the plants would be clustered in the Sacramento and San Joaquin Valleys, and the Mojave and Colorado Deserts (Figure 1). Coastal sites for nuclear power plants are extremely limited due to these criteria.

The 28 new nuclear power plants represent an addition of 29,500 MW to the total generating capacity of the state by 1995 (Figure 2). This represents only about half of the additions to capacity planned by the utilities, but it will be the largest single source of power generation by the end of the next twenty years. Other features of the plans of the utilities are significant:

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[1]Submittals of Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), San Diego Gas and Electric Company (SDG&E), and the Los Angeles Department of Water and Power (LADWP) to the State Energy Resources Conservation and Development Commission, dated March 1, 1976, plus conversation with representatives of PG&E, April 14, 1976.

Figure I

CALIFORNIA NUCLEAR POWER PLANTS

1975 - 1995

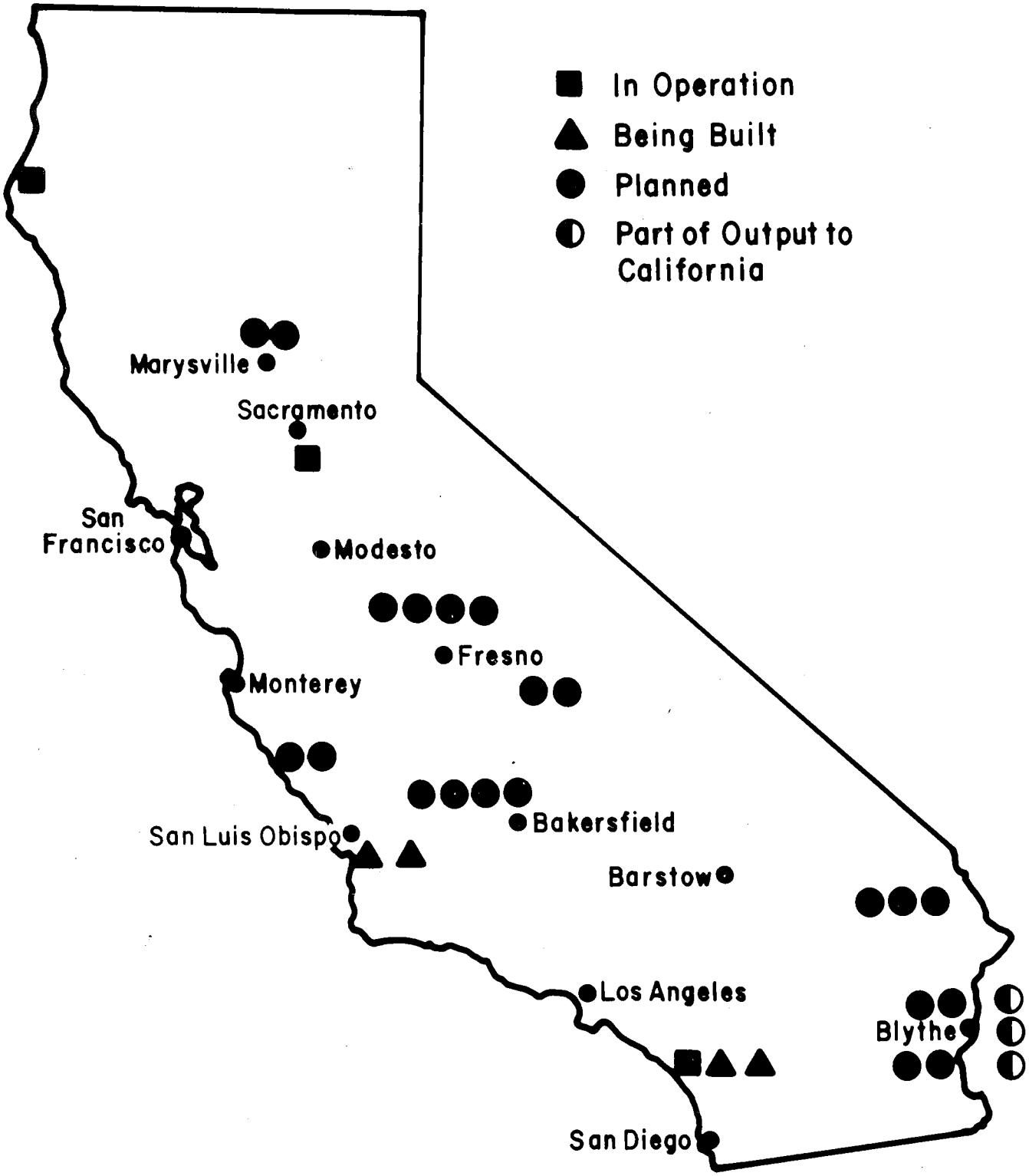
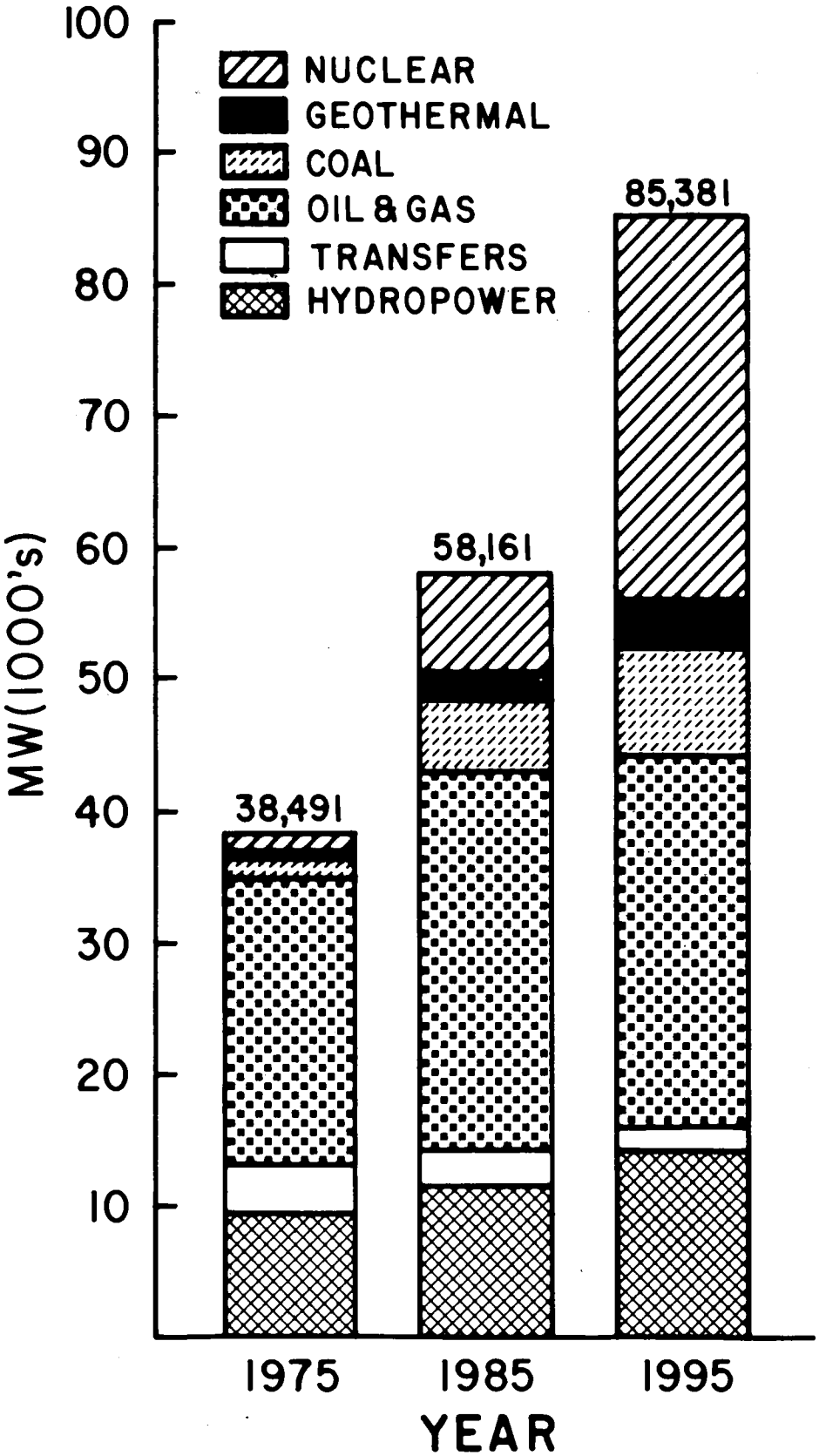


Figure 2

PLANNED GENERATING CAPACITY ALL CALIFORNIA UTILITIES



DATA FOR FIGURE 2:

GENERATING CAPACITY - ALL CALIFORNIA UTILITIES

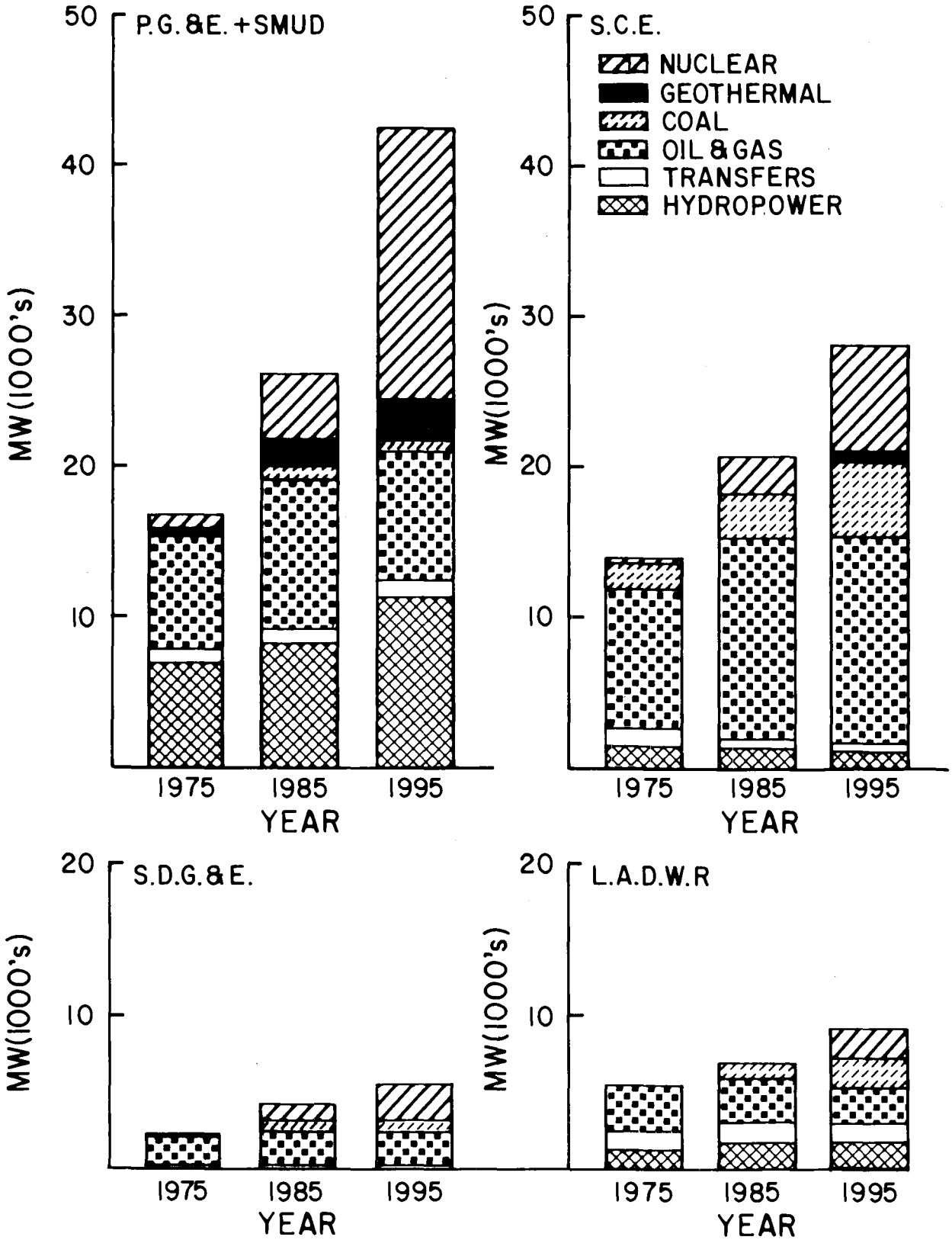
	1975		1985		1995	
	MW	%	MW	%	MW	%
Nuclear	1,379	4%	7,823	13%	29,522	35%
Oil & Gas	21,813	57%	28,572	49%	27,268	32%
Coal	1,653	4%	5,570	10%	8,370	10%
Geothermal	502	1%	1,898	3%	3,258	4%
Transfers	3,402	9%	2,872	5%	2,601	3%
Hydropower	9,742	25%	11,456	20%	14,362	17%
TOTAL	38,491		58,161		85,381	

Annual Growth Rates:	1975 - 1995	4.1%
	1975 - 1985	4.2%
	1985 - 1995	3.9%

(1) Over 5400 MW of new oil-fired power plants are planned despite the expectation of continued high oil prices. (2) Coal-fired plants are to be constructed at a rate second only to nuclear plants. (3) Some utilities are planning to rely much more on nuclear power in the futre than are others (Figure 3). PG&E and SMUD together expect 42% of their capacity to be nuclear, and SCE will primarily be using oil- and gas-fired units (48% of 1995 capacity). SDG&E also plans a strong nuclear program (44% of its capacity by 1995) while LADWP will balance its resources nearly equally among nuclear (21%), out-of-state coal (20%), oil (26%), and hydropower (20%). These plans have been changing rapidly. In the last six months, the utilities have dropped their projected needs for new power plants in the next twenty years by 6000 MW and have postponed in net terms 3 large nuclear units. Additionally, greater success in energy conservation and the development of novel energy sources could substantially alter the utility plans. The significant of the uncertainty in the utility plans will be pointed out in the discussion of reassessment mechanisms.

Figure 3

PLANNED CAPACITY ADDITIONS FOR
INDIVIDUAL CALIFORNIA ELECTRIC UTILITIES



DATA FOR FIGURE 3:

GENERATING CAPACITY FOR INDIVIDUAL UTILITIES
(Megawatts)

	P.G. & E. plus S.M.U.D.			So. California Edison		
	1975	1985	1995	1975	1985	1995
Nuclear	949	4,319	18,007	344	2,501	7,137
Oil & Gas	7,488	9,863	8,798	9,352	13,458	13,752
Coal	-0-	800	800	1,653	2,891	4,971
Geothermal	502	1,898	2,608	-0-	-0-	650
Transfers	947	996	889	1,157	628	520
Hydropower	6,929	8.266	11,309	1,523	1,326	1,189
TOTAL	16,815	26,142	42,411	14,038	20,804	28,219
Annual Growth Rate 1975 - 1995		4.7%			3.6%	

	L.A. Dept. of Water & Power			San Diego Gas & Electric		
	1975	1985	1995	1975	1985	1995
Nuclear	-0-	-0-	1,900	86	1,003	2,478
Oil & Gas	2,995	2,869	2,336	1,978	2,382	2,382
Coal	-0-	1,124	1,874	-0-	725	725
Geothermal	-0-	-0-	-0-	-0-	-0-	-0-
Transfers	1,126	1,214	1,174	172	34	18
Hydropower	1,281	1,864	1,864	-0-	-0-	-0-
TOTAL	5,402	7,071	9,148	2,236	4,144	5,603
Annual Growth Rate 1975 - 1995		2.7%			4.7% (1975 - 1985 6.4%)	

CHAPTER THREE

IS A REASSESSMENT NECESSARY?

Critics have a large catalog of problems they see in the nuclear power program. In some cases the evidence indicates elements of both the nuclear industry and government have agreed that problems do exist. These agreed upon or "stipulated" problems include:

1. The absence of any accepted nuclear waste disposal method.
2. A near-term shortage of spent fuel reprocessing capacity.
3. Near-term fuel enrichment capacity inadequacies.
4. Exceptionally rapid construction and fuel cost increases.

Nuclear power proponents find these difficulties manageable and temporary. Critics see a more profound meaning in the occurrence of such problems in basic components of the nuclear program, believing they (a) eliminate in part the rationale for using nuclear power in the first place and (b) signal the existence of other problems not yet acknowledged.

The remaining questions that have been raised are contested by the industry, the Federal Government, and their critics. The list of these alleged problems includes:

1. The risk of a catastrophic reactor accident.
2. Long-term uranium supply and the implicit commitment to the breeder reactor, raising other safety questions.
3. The reliability of large nuclear plants and whether they breakdown more often than conventional plants.
4. Risks to the public from accidents during the transportation of spent fuel.
5. The protection of bomb-grade fuels (mostly plutonium) from theft.
6. The implications of the necessity for perpetual isolation of nuclear wastes.

7. Limits on the liability of utilities and reactor manufacturers for the consequences of any nuclear accident.

In this list, the question that has received the most public attention is the likelihood and consequences of a major malfunction at an operating nuclear plant. In an attempt to resolve the question, a reactor safety study was conducted by the Federal Government, but has itself become the center of controversy. Proponents believe the issues posed by all six problems have been dealt with rigorously through conservative engineering and close regulation by Federal agencies. Critics point to incidents and considerations which raise doubts about the actual degree of engineering conservatism and contend that the Federal agencies are not doing their job.

The nuclear power program in this country has been sold largely as way to provide safe, clean, reliable, cheap energy. Challenging any of these premises calls into question the wisdom of the entire program. In challenging these assumptions, the critics raise problems which fall into four generic categories:

1. Radiologic safety, the potential for massive releases of radioactive materials both from the reactor and from spent fuel transportation.
2. Disposal and sequestering of nuclear wastes over the long term.
3. Blockages and shortages in the nuclear fuel cycle.
4. Economic viability of nuclear power.

In each of these categories, the supporters of nuclear power admit there are some problems. They minimize the long-term significance of these problems, though. The critics allege a long list of serious problems all of which question fundamental assumptions in the nuclear power program.

A. REACTOR FUNDAMENTALS[2]

Most of the 58 nuclear power plants that are operating and the 166 under construction or on order in the United States use "light-water" reactors to generate nuclear power. A few will use "high-temperature, gas-cooled" reactors. For the fairly distant future, government and industry research and development efforts are concentrating on the "breeder" reactor, which is expected to produce more nuclear fuel than it consumes and thus provide a virtually limitless supply of energy.

Because the safety issues raised by nuclear power opponents relate in large part to the ways nuclear power is generated, it is important to understand some fundamentals of nuclear technology.

The Light-Water Reactors

There are two kinds of light-water reactors: pressurized-water reactors (which are manufactured by Westinghouse, Babcock & Wilcox and Combustion Engineering), and boiling-water reactors (which are made by General Electric). Light-water reactors run on energy created by the fission, or splitting, of uranium atoms, which throw off two or three neutrons and release heat in the process. The neutrons in turn run into other atoms, dislodging more neutrons and, if properly controlled, setting up a chain reaction and providing a steady source of heat.

U.S. reactors require a complex fuel cycle involving steps of mining, enrichment, fabrication, reprocessing and waste

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[2]This section relies heavily on a similar discussion in The Nuclear Power Alternative, Investor's Responsibility Research Center, Washington, D.C., 1975, (hereinafter cited as The Nuclear Power Alternative).

disposal. The light-water reactors in operation now use "enriched" uranium, containing about 3 percent of the isotope U-235, as their fuel. Natural uranium contains less than 1 percent U-235; almost all the remainder is U-238. The proportion of U-235 is increased through a complex gaseous diffusion process at special AEC (now ERDA) facilities.

For use as a reactor fuel, the slightly enriched uranium is oxidized and formed into fuel pellets, which are placed into 12-foot rods clad in zirconium alloy. The rods are assembled in bundles and placed vertically in the reactor core. The reactor core is surrounded by a heavy steel pressure vessel, and the pressure vessel and supporting cooling systems are placed inside a large reinforced-concrete containment dome. The chain reaction is controlled by rods--usually made of boron--which are partially raised from the reactor core and by boric acid which circulates in water around the fuel bundles. Boron is a neutron-absorbing element; when the rods are dropped into the fuel core, the boron absorbs neutrons being thrown off by the splitting atoms and controls or halts the chain reaction. Removal of the control rods from the core starts up the reactor; thrusting them back into the core terminates, or "scrams," the reactor's operation.

As the uranium in the fuel fissions, radioactive fragments begin to build up in the zircaloy tubes. Eventually these fission products reduce the efficiency of the nuclear chain reaction and the fuel must be pulled out and replaced with fresh fuel bundles. Not all the U-235 has been consumed in the spent fuel and some of the U-238 has been converted into plutonium-239 which is fissionable itself and can be used as a reactor fuel. To

economize on the use of uranium, the spent fuel is sent off to a reprocessing plant where the rods are chopped up, the fission products extracted and the remaining uranium and plutonium returned for refabrication into fuel. The radioactive debris is now temporarily stored waiting for the Federal Government to decide how ultimately to get rid of it. These wastes are intensely radioactive and must be isolated until they have decayed to stable, harmless elements. For most of the debris this process requires about 1000 years; for other products in the waste several million years are required.

The boiling-water reactor: In a boiling-water reactor, the heat from the fission process-contained in the reactor core-boils water which is passing through the core and thus creates steam. The steam drives the turbines that generates the electricity. After the steam passes through the turbines, it is condensed, and the water formed is returned to the reactor core. There, the water is boiled again, cooling the reactor core in the process.

The pressurized-water reactor: A pressurized-water reactor operates in much the same fashion, except that the water is kept under pressure which prevents it from becoming steam and the radioactive coolant is isolated from the steam turbine by a heat exchanger. The heated water flows through the heat exchanger, where it is cooled, and water in a secondary system is boiled to create steam to drive the turbine.

The high-temperature, gas-cooled reactor: The high-temperature, gas-cooled reactor (HTGR) will probably not play a significant

role in the nuclear reactor market. Recently General Atomic Corporation decided to abandon its reactor division. Only two reactors of this type are now in operation in the U.S. They use highly enriched uranium fuel and circulate helium under high pressure to transfer heat to make steam that turns the turbine-generator. The HTGR uses a stressed concrete pressure vessel rather than the steel tank common to LWR's. Because there are no exposed coolant lines, some have argued that HTGR's are inherently safer than LWR's.

The Breeder Reactor

Some of the most controversial issues in the nuclear power debate involve the liquid-metal fast-breeder reactor (LMFBR). The LMFBR produces, or "breeds," more fuel than it consumes. Plutonium, initially produced in light-water reactors, is used together with uranium-238 in the breeder fuel assembly. The fission process in the reactor produces additional plutonium which, in turn, is used with more U-238 to fuel more LMFBRs. Because more than 99 percent of natural uranium is U-238, breeder technology would dramatically extend uranium reserves. The LMFBR uses liquid sodium as a coolant, generates higher temperatures than the light-water reactor and operates at 40-percent efficiency.

The breeder program is the federal government's largest energy research and development project; it consumes about 40 percent of the energy R & D budget. Estimates of the cost of the demonstration plant escalated during 1974 from the $400- to $500-million range, to close to $1.7 billion. Projected costs of the overall program have jumped from $3.9 billion in 1971 to $6.4

billion today.

The first LMFBR demonstration plant, being built near Oak Ridge, Tennessee, was scheduled to be in successful operation by 1980; commercial introduction of the LMFBR was expected by the mid-1980s. Now Robert Seamans, Chief of the Energy Research and Development Administration (ERDA), has decided to slow down the joint government-industry project stating, "the project has built up too rapidly."[3]

B. STIPULATED PROBLEMS

While generally the nuclear industry does not believe there are serious problems in our nuclear power program, recently the volume of complaints and level of frustration of the industry has increased. Several witnesses publicly agreed that portions of the program were now in trouble. These troubles are largely economic or the result of poor planning, not safety-related. We refer to these problems as "stipulated" because so many in the industry and in the Federal Government agree that they exist, but opinion is not unanimous.

1. No Demonstrated, Accepted Nuclear Waste Disposal Method

The disposal of intensely radioactive wastes is now the responsibility of the federal government. While several disposal methods are now under investigation, none have come to a commercial stage of development. The problems are both in finding

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[3]Quoted in "Why Atomic Power Dims Today", Business Week, November 17, 1975, p. 106.

techniques to solidify the high-level wastes now stored in liquid form and in finding disposal methods for the solidified material. The problem was officially recognized by ERDA (the agency with direct development responsibility) in a March, 1975 report[4] and by NRC Commissioner Mason who said in September 1975:

> "Simply stated, although several available technologies have been researched, demonstration scale information is lacking and no agreed-upon plan for long-term high level waste management exists."[5]

Historic Emphasis on Disposal in Deep Salt Beds: AEC/ERDA programs until recently were directed primarily at one approach--disposing of wastes in ancient salt beds. In discussing the rationale for this, an ERDA spokesman explained: "Placement of high level waste in deep, stable geological formations was recognized years ago as the most promising way to avoid prolonged maintenance of man-made storage systems. The National Academy of Sciences (in 1955) identified bedded salt formations in the continental United States as suitable geological formations for this purpose."[6]

Specific Salt Sites Found Unsatisfactory: Detailed salt site investigations to date have not been successful. A site

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[4]"Major aspects of safe disposal of radioactive waste have not been demonstrated, and certain treatment procedures have not even been developed," Energy Research & Development Administration, The Nuclear Fuel Cycle, ERDA-33, March 1975, p. 30 (hereafter cited as Nuclear Fuel Cycle).

[5]NRC, 1975, quoted in Transcript, Nov. 5, p. 3.

[6]Transcript, November 4, 1975, p. 5.

at Lyons, Kansas had to be abandoned completely in 1972[7] and an alternate site in New Mexico has recently been found unsatisfactory.[8] Though ERDA is optimistic a nearby New Mexico site will be "very satisfactory", a representative said "We are not making any promises..."[9]

The latest plan. Due to the disappointments in the salt burial pilot tests the AEC planned to store wastes temporarily in a surface vault to provide more time for discovery of a permanent disposal method.[10] This action led to criticism that the nation was climbing out on a limb with no assurance of being able to climb back off: Is it wise to produce such toxic wastes before knowing what to do with them? When ERDA was created in January, 1975, it took over responsibility for the wastes management program. In April, 1975 ERDA called a halt to plans for "interim storage" pending a closer look. A year later in March, 1976 ERDA asked Congress to double its waste management budget for 1977--$151.8 million, up from $81.4 million in 1976.[11] Before 1975, waste disposal programs had been receiving less than $5 million annually. The new program places a heavy emphasis on an expanded search for

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[7]Transcript, November 5, 1975, p. 8.

[8]Transcript, November 4, 1975, p. 26.

[9]Ibid.

[10]Reardon, Transcript, November 4, 1975, p. 6.

[11]The budget figure includes both military & commercial nuclear waste programs. The increase is mostly for the commercial side, from a current $119 million to a proposed $59.9 million.

permanent disposal methods, but the possible use of interim storage has not been ruled out.

Critics point to the new budget request as an admission that the program had been neglected for years and as a contradiction of prior AEC claims that the problem was well in hand.

Position of the U.S. Environmental Protection Agency.[12] Considering waste disposal "perhaps the most serious issue confronting nuclear power", William Rowe, Deputy Assistant Administrator, Office of Radiation Programs, in EPA stated:

> "If a safe, ultimate disposal method is not found quite soon, expanded or even continued nuclear energy from the fission process would be very difficult to support. We believe that the answer to this question can be put to rest; however, this must be done before substantially greater commitments are made."[13]

Rowe defined "greater commitments" as "commitments beyond those numbers of reactors that have already been operated or are under construction".[14] He qualified his comments by noting that civilian reactor wastes are a small percentage of the waste left over from the weapons program, and will represent only 6-8% of the weapons wastes even in 10 years.[15] EPA noted that three or four disposal methods look promising and it is now a matter of picking the best

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[12]EPA shares responsibility for radiation protection with the NRC and has reviewed ERDA's waste management program Environmental Impact Statement. EPA is in the role of looking over the shoulder of several other Federal agencies.

[13]Transcript, November 18, 1975, p. 50.

[14]Ibid., p. 51.

[15]Ibid., p. 58.

one, hopefully within the next ten years.[16]

Comments from the industry: Recognizing the embarrassing position the failure to find a disposal method has put them in, industry spokesmen have stated they wish to see the government speed up its decision-making, and expressed dismay at federal funding problems.[17] In turn, EPA indicated in testimony that most of the research or disposal has and is being done by the industry and that "an awful lot of the money" is going to come from industry as an equal partner in finding the solution.[18]

Beyond the publicity aspects of the lack of disposal method, the industry does not believe the problem really constrains further nuclear development. Pending solution, commercial reactors will produce a cumulative total of only about 10 million gallons of high-level (intensely radioactive) waste by 1985. This volume of liquid, according to the industry, is easy to manage.

2. A Shortage of Fuel Reprocessing Capacity

An important factor in the low cost of nuclear power has been the planned recycling of unused fuel from reactor wastes. But no fuel reprocessing plants are now operating and fuel is not being recycled. Three reprocessing plants have been built, but one (built by GE) is considered technically inoperable; a second in New York, owned by Nuclear Fuel Services (NFS), is closed for extensive modifications requiring complete relicensing

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[16] Transcript, November 18, 1975, p. 50.

[17] Transcript, November 4, 1975, p. 68 and Transcript December 9, 1975, p. 9.

[18] Transcript, November 18, 1975, p. 52.

and a third, the AGNS plant in South Carolina, is nearing completion but delays and unpredictable changes in the licensing process raise serious 'uncertainties' regarding the start-up and continued operation of the plant.[19] Much of the delay is caused by opposition to the recycling of recovered plutonium back into reactor fuel. The Nuclear Regulatory Commission has been grappling with this decision for months and will not allow any fuel to be reprocessed until the question is resolved.[20]

Possible plant shutdowns due to inadequate fuel storage space. While the reprocessing plants are inoperative, reactors continue to produce spent fuel. The waste fuel is now being stored at the New York reprocessing plant and at individual power plants. Over 1000 tons of spent fuel has now backed up in the fuel cycle. Reactor operators try to maintain enough storage space at power plants to handle a fuel core in emergencies. At least 10 reactors may have to shut down in the next two years because of inadequate storage space unless temporary facilities can be built.[21] To prevent shutdowns, ERDA noted that additional storage capacity must be ready by 1977 and more capacity equal to the amount of fuel discharged is needed every year thereafter

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[19]Transcript, Nov. 4, pgs. 62, 98, 99, 183.

[20]The NRC is planning, however, to license reprocessing plants by early 1977 on an interim basis allowing uranium recovery and recycling without plutonium recycling. Some use of existing stocks of plutonium in a mixed oxide fuel may also be allowed on an "experimental basis", without committing to massive plutonium recycling on a commercial scale (Nucleonics Week, Nov. 13, 1975, p. 1).

[21]Nuclear Fuel Cycle, p. 22.

until the reprocessing plants begin to operate.[22]

Known plants soon to be inadequate. Even if utilities come up with a way to store more fuel, by 1982 the spent fuel from the nation's nuclear plants will exceed the combined capacity of the AGNS and NFS plants.[23] To alleviate the blockage, a new reprocessing plant the size of the AGNS facility will be needed by 1982 and similar ones every 18 months thereafter.[24] But new plants may take up to 10 years to build. Given the delays of the NRC in granting permission for the AGNS and NFS plants to operate, companies are understandably reluctant to commit to any new investment in the reprocessing enterprise. AGNS itself is a victim of massive cost overruns (costs initially projected at $80 million now estimated at $600 million) and may require substantial Federal aid.[25] A continued shortage in reprocessing capacity seems inevitable.

Shaky economics. AGNS notes that with the uncertainties and delays, the current state of affairs in reprocessing "is not a very satisfactory business situation."[26] Growing out of their dismal experience in building an inoperable reprocessing plant, GE questions whether reprocessing can or even should

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[22] Nuclear Fuel Cycle, p.22.

[23] Ibid., p. 24.

[24] Ibid.

[25] Transcript, November 5, 1975. p. 50.

[26] Transcript, November 4, 1975, p. 104.

be a commercially viable business.[27] Initial estimates for reprocessing were about $30 per kilogram of fuel. Now the estimates range from $100 to $200 per kg.[28] At these prices it may actually cost more to reprocess the fuel than the reclaimed uranium and plutonium is worth.[29]

Industry reaction. The absence of reprocessing and the temporary storage probably does not pose serious safety problems. But according to AGNS, "it does represent an economic embarrassment of the highest sort."[30] The failure to reclaim unused fuel will put greater demands on uranium mining, milling and enrichment activities--more raw fuel will be needed for every kwh produced. ERDA comments that, while fuel reprocessing plants do not have to operate in order for there to be a commercial nuclear power industry, reprocessing could result in lower power costs and a more rapid expansion of the number of reactors operating.[31] Chauncey Starr, president of the utility-financed Electric Power Research Institute, advises that "the absence

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[27] Bertram Wolfe, (General Electric), 1975. "The Back End of the Fuel Cycle", paper presented to the Atomic Industrial Forum, Fuel Cycle Conference-75.

[28] Nuclear Fuel Cycle, p. 25.

[29] Transcript, November 5, 1975, p. 50.

[30] Transcript, November 4, 1975, p. 177.

[31] Nuclear Fuel Cycle, p. 41.

of closure of the full fuel cycle cannot go on indefinitely."[32]

3. Inadequate Enrichment Capacity

Early last year, ERDA announced that there is "insufficient existing enrichment capacity to support the projected growth of the industry beyond about 1983."[33] Presently all enrichment is conducted by the Federal Government (which will spend almost $1 billion between now and 1981 to maintain and upgrade existing capacity). Since 1971, the Federal Government has been enticing private industry to get into the enrichment business rather than use tax money for the $30 billion expansion which may be needed in the next 15 years. Originally, several large industries rejected the government's encouragement because of the huge amounts of capital needed. President Ford has responded with a bill in Congress (the Nuclear Fuel Assurance Act) which would set up a system of technological and financial backstops for private enrichment ventures.[34] Four companies or groups of companies have now made proposals, and three involve an untried gas centrifuge technology. The success of these proposals appears to be tied to the success of the President's proposal to Congress which still has not been acted on. Even if congressional action is taken, though, some in industry are

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[32]"Why Atomic Power Dims Today," Business Week, November 17, 1975, p. 106 (hereinafter cited as "Why Atomic Power Dims Today")

[33]Nuclear Fuel Cycle, op. cit., p. viii. Enrichment contract brokers, in order to line up more capacity, have looked into enrichment contracts with the USSR to supply US nuclear power plants (Nucleonics Week, May 6, 1976, p. 1).

[34]Nucleonics Week, January 23, 1976.

unsure whether additional enrichment capacity will come in time to forestall cutbacks in reactor orders.[35] Says A. L. Bethel, vice-president of Westinghouse's reactor division, "We don't particularly care who does the enrichment, but they have to get on with it. Otherwise we are going to have trouble selling these things."[36]

4. Rapid Cost Escalations for Nuclear Power Plants

Estimates that nuclear power plants will produce electricity cheaper than coal or oil have become less optimistic, and some say the situation is now reversed.[37] In the past eighteen months, utilities have cancelled or deferred 105,000 MW of nuclear capacity. Among the five major reactor manufacturers, only Westinghouse claims to be in the black. General Atomic Company, a joint venture of Gulf Oil Corporation and Royal Dutch Shell, succumbed to the grim situation in 1975 and dropped out of the reactor business.

The troubles in the industry are not solely due to escalating costs. A downturn in electricity demand has been a significant contributor. But licensing delays, construction hangups, and increasing disappointments in portions of the fuel cycle are being reflected in higher costs which seem to overwhelm other

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[35]Transcript, December 10, 1975, p. 61.

[36]"Why Atomic Power Dims Today", p. 103.

[37]Steven Moody, having done a study for the nonprofit Council on Economic Priorities, concludes: "The ability of nuclear plants to produce electricity at a low cost per kwh has been overstated by most nuclear proponents. New nuclear plants will generally not cost less to own or operate than new coal-fired plants." (Transcript, December 3, 1975, p. 217). Utilities seem to be increasingly planning for coal plants rather than nuclear nationwide, but the number making such plans is still small (Nucleonics Week, July 10, 1975, p. 3).

considerations. Pacific Gas and Electric Company has now hedged its bet on a heavy nuclear commitment by making a down payment on low sulfur coal reserves in Utah. In a trade journal, economic considerations were emphasized as major reasons for delays and cancellations: "Soaring costs have been charged with forcing seven major units off the schedule this year [1975]".[38] In January, 1976, the Sacramento Municipal Utility District suspended its plans for a second nuclear unit at Rancho Seco when estimated costs jumped from $853 million to $1.32 billion.[39]

The increased costs are reflected in both construction costs and fuel costs. Between 1969 and 1975 the price for a kilowatt of new nuclear capacity jumped from $226 to $868.[40] Spent fuel reprocessing charges are estimated to be as high as $350 per kilogram, up from an original estimate of $35 per kilogram.[41] Enrichment tolls at the government-owned plants have been inching up in support of a policy decision to price the service on a par with the fledging private enrichment industry the administration is attempting to create. For parity it is estimated the recent charge of $53 per separative work

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[38]"Nuclear Survey: Cancellations and Delays", Electrical World, October 15, 1975, p. 35.

[39]Draft and Final Environmental Impact Statements, Rancho Seco 2, Sacramento Municipal Utilities District.

[40]Nucleonics Week, December 11, 1975, p. 7.

[41]Ibid.

unit must climb to $100.[42] The lack of uranium and plutonium recycling from spent fuel is estimated to add $10 million per year to the fuel costs of each reactor.[43] Finally the price of raw uranium has been climbing sharply, tripling since the late 1960's. Westinghouse contracted with its reactor purchasers to sell them uranium at no more than $8 per pound. With the current price of uranium at $39 a pound (some 1976 contracts negotiated at almost $50/lb.),[44] Westinghouse stood to lose at least $1 billion. Instead it announced it would not honor its contracts, arguing that events beyond its control made it commercially impossible to meet those contract conditions. Currently, 14 of the 20 affected utilities have taken Westinghouse to court. Mitchell, Hutchins, Inc., investment counselors, are predicting price increases to "...$100/pound over the next year, quite possibly rising two to three times this level thereafter before eventually settling down."[45]

Increases such as these, coupled with other fuel cycle-cost escalations have produced an annual 25% increase in the estimated cost of producing electricity in nuclear plants, a much more rapid rate than the comparable figures for a coal plant, but less than for an oil-fired plant.

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[42] ERDA believes $76/SWU may be high enough, but the commercial price is estimated at $100/SWU (Nucleonics Week, Oct. 2, 1975, p. 8).

[43] Nucleonics Week, April 15, 1976, p. 2.

[44] National Observer, April 24, 1976, citing Nuclear Exchange Corp. (NUEXCO), see also Nucleonics Week, October 23, 1975.

[45] David Snow, "The Uranium Stocks: Nuclear Industry Kaleidoscope Coming Together", Mitchell, Hutchins, Inc., New York.

Electrical World, a utilities trade magazine, in a recent survey, listed nuclear power as the second most costly way to make electricity, second only to oil; coal was fourth, 25% less than nuclear.[46] This ranking is disputed by the Atomic Industrial Forum which reported from its own survey that the average cost of electricity from nuclear reactors is 30 percent less than that from coal-burning power plants. While the discrepancy is puzzling, it is a clear demonstration of the great range of uncertainty facing utility planners. The unexpected and disproportionate price hikes for nuclear plants have been unsettling. One investment portfolio manager remarked, "To launch a new project to build a nuclear facility, utility management must be courageous, or as some say, naive."[47] Others believe the cost escalations will not continue and in time the cost situation with coal plants will sour as more restrictions are placed on their pollution output and expensive abatement equipment must be added.

C. ALLEGED PROBLEMS.

While nuclear power proponents admit to some problems in using nuclear power and admit that if not properly managed the potential for danger is great, they believe the problems have been dealt with sufficiently through various engineered safety measures and design conservatism so that the public is well protected. The critics see many of the same dangers but do

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[46] Leonard Olmstead, "19th Steam Station Cost Survey", Electrical World, November 15, 1975, pp. 43-58.

[47] Weekly Energy Report, December 15, 1975, p. 9.

not agree that the safety measures taken in fact assure adequate protection of the public. To support their view they cite a number of recent unexpected or unanticipated errors and malfunctions in reactor operations and express a general skepticism of the human infallibility they believe is required to guarantee safe operation. On both sides the evidence cited is incomplete and speculative since experience is limited; it becomes a matter of the degree of trust one has in the speculations of the organizations and individuals on each side. The scientists are on both sides of these issues.

1. REACTOR SAFETY

The fissioning of the atom produces materials which are potentially very hazardous and must be carefully confined in the reactor. To ensure safety, an agency of the Federal Government (the Atomic Energy Commission, now the Nuclear Regulatory Commission) was created to regulate the use of nuclear power to ensure adequate protection. The basic design philosophies for safety include multiple barriers to contain radioactive material and emergency systems to maintain the integrity of the barriers. A recent Federal Government study concluded that if these safety devices were breached, a reactor accident could cause 3300 fatalities, make 45,000 people ill, damage $14 billion worth of property, and contaminate a 3200 square mile area. But the probability of such a catastrophic accident was estimated to be about one in 10,000,000 per year (with 100 reactors in operation), less than the chances of a major dam failure, airline accident, fire or earthquake.

Critics challenge the validity of this conclusion on several grounds: (1) the methodology was inappropriate; (2) human fallibility was not properly accounted for; (3) recent unexpected malfunctions indicate component failures or design inadequacies more likely than assumed, and (4) safety systems have not been tested and may not work when needed. The critics believe the study created overconfidence in

present systems and approaches and was based on optimistic assumptions. Nuclear power proponents note that even though there have been some malfunctions at reactors and some safety devices have failed, there have been enough back-up systems so that no radioactive material has ever been released which imperiled the public. Proponents attribute this good safety record to vigorous regulation and good design. An independent study of reactor safety by the American Physical Society concluded that not enough was known about certain reactor conditions and emergency system performance to verify that the design assumptions were in all cases conservative.

Hazards of Nuclear Plants Potentially Large. While most concern focuses on the nuclear power plants themselves, it is argued that the public is at risk in one way or another in all parts of the nuclear fuel cycle.

An operating 1000 MW light water reactor--the size now commonly being built--contains a large amount of radioactive material.[48] All authorities agree that the release of large quantities of radioactivity could have serious effects. High levels of radiation exposure can cause almost immediate death. Low exposures can lead to various cancers (thyroid, lung, bone) or genetic damage which only show up after long latent periods. One critic notes that a quarter of the inventory of radioactive iodine would suffice to contaminate the atmosphere of the 48 states to an altitude of 10 km to twice the maximum permissible concentration (established by the National Committee on Radiation Protection), and half of the strontium 90 inventory could

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[48]Between refueling operations, a reactor operating at full power accumulates in the order of 1.7×10^{10} curies of radiosotopes. (Report to the American Physical Society by the Study Group on Light Water Reactor Safety, Reviews of Modern Physics, Vol. 47, Supplement No. 1, Summer 1971 (hereinafter cited as "APS Report") p. S-23).

contaminate the total annual freshwater runoff of the same area to six times the maximum permissible concentration.[49] This estimate is not to suggest that such dispersion could in fact occur but only to provide some perspective on the volume of hazardous material one reactor represents and the extreme caution it merits.

The largest fraction of the radioactivity in the reactor is due to the fragments produced in the fissioning of uranium. The remainder of the radioactivity is the result of the capture of neutrons by the reactor structural material or the portion of the fuel which is not fissionable. Once the reactor shuts down the generation of radioactive material ceases and the quantity of radioactivity decreases, initially at a very rapid rate, due to the decay of very short-lived fission fragments. This decay process itself generates heat, though. Immediately after shutdown, a 1000 MW (e) (3300 MW thermal) reactor generates 225 MW (thermal) of afterheat, about 7% of the heat at full power. It is the need to remove this residual heat after shutdown which leads to the concern over many of the safety features of reactors.

At other points in the nuclear fuel cycle, radioactive materials are also present. The greatest amounts of this material outside the reactor are handled in the transportation of spent fuel, reprocessing, and nuclear waste disposal, all requiring extreme caution.

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[49] John P. Holdren, "Hazards of the Nuclear Fuel Cycle", Bulletin of the Atomic Scientists 30:14 (1974)

Safety Regulation to Assure Public Protection. Because of the potential hazards of the careless use of nuclear power, the government created in 1946 the Atomic Energy Commission, to control the use of the atom, to promote its peaceful use, and to safeguard the public. In 1954 Congress and the President took steps to create and encourage a private nuclear industry under the scrutiny of the AEC. Over the years the AEC established an extensive set of criteria and standards controlling the commercial use of nuclear power and required the detailed design of every proposed reactor to be closely examined before authorizing its construction and operations. In 1975, owing to complaints that the functions of promotion and regulation were incompatible in the one agency, the functions were split. The Nuclear Regulatory Commission (NRC) was given the job of being the impartial judge of safety and the Energy Research and Development Administration (ERDA) was given the task of promoting nuclear power along with a number of other energy options.

At every stage in the fuel cycle, a small portion of the radioactive materials leak out. The NRC is now responsible for putting maximum limits on the levels of these normal operating releases and the levels are now set so low that most believe they are of minor consequence.[50] NRC regulations protect

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[50]However the present low emission levels were established after a controversy, which at its height lasted two and a half years, set off by criticisms that the original level posed too great a hazard. In 1972 the AEC dropped the permissible level by a factor of 30, while cautioning that overall medical x-rays were probably of more concern.

workers in the nuclear plants from overexposure to radioactivity. And it is the NRC whose job it is to see that there will not be serious accidents at reactors or elsewhere in the fuel cycle. It is the fear of high exposure levels from accidents that is the reason for most of the critics' concerns.

Major Reactor Accident Possibilities. The industry and Federal Government regulators have designed a concept which they feel will protect the public from the release of large amounts of radioactive material from the reactor during both normal and abnormal operation which involves three levels of safety.

1. Almost all of the radioactive material is contained within the ceramic-like uranium fuel pellets which are themselves enclosed in metal (zircaloy) rods.

2. The fuel rods are sealed inside an extremely strong steel pressure vessel and coolant piping.

3. The entire reactor coolant system and pressure vessel is enclosed in an air tight containment structure designed to confine and trap any radioactive material which might escape.

A large fraction of the radioactive material can only be released if the fuel itself were to melt. It becomes crucial then to ensure adequate cooling to prevent melting the fuel core and the critics are skeptical about the actual adequacy of the three levels of safety.

Major concern has been centered on a postulated loss of coolant accident (LOCA) and its consequences.[51] The cause of

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[51] It is understood now that serious problems can occur in a reactor without a LOCA so that there is probably too much attention given the LOCA and too little to other abnormal reactor conditions. But because of the historical significance of the LOCA and the central role it has played in designing reactors to cope with it, this report goes into some detail on the problem.

a LOCA would be a break in the main cooling system, either one of the coolant lines or the pressure vessel itself. The water in the system is under high pressure and would be rapidly expelled if a large break occurred, leaving the core dry. Residual decay heat would then begin to melt the core unless additional cooling water is supplied. If the coolant is not available in time, the core might melt into a molten mass hot enough to burn its way through the pressure vessel and possibly through the containment building. By breaching all three safety levels, radioactive materials would escape and potentially could cause considerable damage.

To guard against the occurrence of a LOCA, nuclear power plants are designed to provide what the federal regulators term "defense in depth". The first level of safety involves conservative design which tolerates errors and malfunctions, and quality assurance for materials and components. The second level consists of "engineered safety features" and redundant back-up systems. The third level is additional safety features designed to handle failures in the first two lines of defense. In this category is included the emergency core cooling system, or ECCS. The ECCS is a reserve water supply and delivery system intended to spring into action in a matter of seconds after a LOCA and prevent the core from melting.

Emergency Cooling Safety Systems Controversial. The reliability and adequacy of the ECCS has been one of the major debates between critics, the industry and the federal regulators.

However, no major loss of coolant accident has ever occurred. In the few cases in which portions of the ECCS were called upon to operate, they generally worked, but occasionally there have been malfunctions.

The nuclear industry and the AEC (now NRC) have expressed confidence that the ECCS will indeed work when needed. Their confidence comes from a substantial amount of research, using scale models in tests and developing mathematical models of reactor operations on computers. Critics claim that some of the tests demonstrate the inadequacy of the ECCS while the industry uses the same test result to confirm their confidence in the computer codes (models).

Computer Codes Alleged to be Inadequate. Critics claim that the mathematical simulations of reactors have consistently failed to predict the course of events in laboratory tests[52] and therefore are inadequate. Proponents respond that the errors are usually on the side of conservatism and in any case, as new data becomes available, the codes are refined and now more expertise is being applied to the task by involving several national labs.[53] Proponents also note that tests and data collected from actual reactors confirm parameters estimated in the computer codes.[54] However the study of reactor safety conducted by the American Physical Society concludes:

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[52]Hocevar, Transcript, Oct. 21, pgs. 49, 53.

[53]Transcript, Oct. 22, p. 16

[54]Transcript, Oct. 29, p. 102.

> Despite qualitative indications of general conservatism within the ECCS Acceptance Criteria, we feel that the experimental data are not adequate to demonstrate convincingly that the integrated ECC systems effects are conservatively prescribed, even if all of the individual pieces were demonstrated to be independently conservative (which they have not been). Therefore, any meaningful quantitative evaluation of system effectiveness, or the ECCS safety margin, must depend upon the adequacy of the system analysis codes. At this time, none of us has been convinced that the current generation of codes is adequate to this purpose.[55]

The computer codes grow in significance because they formed the basis of a set of acceptance criteria adopted by the AEC for judging the adequacy of ECC systems in proposed power plants. The controversy lead to an extensive set of rulemaking hearings before the AEC, requiring 125 days of hearings and generating 22,000 pages of transcript. At the conclusions of tnese hearings, the AEC did modify its interim criteria. But the critics were not totally happy with the outcome. They charge the AEC arranged procedures to deny critics the rights of subpoena, cross-examination, and discovery in addition to narrowing the scope of the hearings excessively.[56] The critics still contend that the "NRC is using shaky and unproven computer predictions as a basis for answering such vital questions as the effectiveness of reactor safety

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[55]APS Report, p. S-41.

[56]Ford, Transcript, Oct. 21, p. 77.

systems".[57]

Defenders of present safety regulations argue that at any one time the NRC has done the best job it could and that better regulations have evolved over time and continue to do so.[58]

LOFT Program Set up to Test ECCS Performance. In 1963 the AEC set out to build a loss of fluid test (LOFT) facility to erase doubts about the adequacy of the ECCS and the computer codes. Over the years the mission of LOFT has continually changed and the program has been delayed in order to include tests on new safety features rapidly evolving in LWR's.[59] Full tests are now slated to begin in early 1977, using PWR fuel bundles in a reactor which produces 55 MW of heat (1/60th the scale of a commercial reactor). Critics maintain that LOFT is coming too late to be useful, since by the time results are available,over 100 reactors would already be in operation in this country. The chairman of the APS study stated he "deplored the rate at which the LOFT tests have been brought to fruition," and notes that it may be 10 years before convincing results are available.[60] The critics feel a lot is at stake with LOFT and that the computer codes may turn out to be surprisingly inaccurate. ERDA, the agency which will conduct LOFT, feels the tests are not nearly so vital, and will only enhance the confidence in computer codes by providing data for incremental improvements.

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[57]Carl Hocevar, quoted in The Nuclear Power Alternative, p. 68.

[58]Okrent, Transcript, Oct. 29, 1975, p. 80.

[59]Reardon, Transcript, Oct. 21, 1975. p. 120

[60]Lewis, Transcript, Oct. 29, 1975, p. 43.

More importantly, the APS report finds that the LOFT series has inherent limitations and will not mimic the behavior of an actual reactor in several major respects.[61] Accordingly the LOFT results will not be conclusive of ECCS performance in nuclear power plants.

Reactor "Transients" Can Also Lead to Meltdown. Until recently, most of the attention on major accidents was directed to the LOCA. New government studies raise the possibility that other unusual reactor conditions could lead to a meltdown. One category of these unusual events called transients -- abnormal, non-equilibrium core conditions, hot spots and the like -- has been singled out as a likely cause of a partial meltdown.[62] Transients may occur as a consequence of operator error or equipment malfunction or failure. Ordinarily a serious transient would trigger a reactor shutdown. Following shutdown, cooling systems would normally operate to keep the core from overheating. Failures in either the shutdown system or the decay heat cooling system potentially could cause a core meltdown. Critics and proponents disagree on the implications of this finding. Proponents feel that the sequence necessary to produce serious consequences from a transient is very unlikely. The critics point to the problem as one more area, only recently discovered, about

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[61]APS Report, p. S-74.

[62]Levine, Transcript, Nov. 19, pgs. 28, 38; U.S. Nuclear Regulatory Commission Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Main Report, NUREG-75/014, October, 1975 (hereinafter cited as "Reactor Safety Study"), p. 38.

which we know very little. ERDA began a series of tests in 1974 in their "power burst facility" (PBF) in part to gain more information about the behavior of a fuel core during a transient.

Earthquakes Can Cause Reactor Accidents. Reactor accidents can be initiated through disruption of piping and control systems by a severe earthquake. One witness indicated that California was one of the worst places in the nation for this type of problem.[63] The industry is confident that nuclear plants can withstand the forces of an earthquake without endangering the public. NRC criteria require a minimum distance between a reactor and an active fault as well as a design which will withstand ground accelerations of 0.5 - 0.66g. Critics are skeptical for two reasons. First, they do not believe all active faults are known. Second, they point out that during the moderately severe San Fernando earthquake (6.6 on the Richter scale) the ground acceleration was measured at 1.25g. Given the limited state of scientific data, critics believe putting reactors in California is too risky. Proponents argue that sufficiently stable areas exist that seismic hazards are not insurmountable.

Dispute Centers on Likelihood and Consequences of Accidents. Proponents admit the possibility of several courses of events which could lead to a major release of radioactive material from a reactor but contend the probability of any of these events is exceptionally low; especially with the safety features which

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[63]Kamins, Transcript, Oct. 28, 1975, p. 94.

are a part of every plant in the U.S. Critics feel the probabilities are much higher than the industry admits to, and that the consequences could be of unparalleled proportions.

Reactor Safety Study Conducted by Government to Settle Dispute. The AEC in 1972 commissioned a comprehensive Reactor Safety Study (RSS), with the mission of analyzing a large number of potential accident sequences and the probabilities of each accident type.[64] This study, released in draft form in August, 1974 and published in final form in October, 1975, concluded that the consequences of a reactor accident were no larger, and, in some cases, much smaller than the consequences of many other accidents to which the public is exposed. The major surprises were that meltdown accidents were more likely than previously imagined, but that their consequences were much less than expected. The study's main conclusions were:

(1) The risks posed by nuclear reactors to both individuals and society are smaller than the risks of fire, air crashes, explosions, dam failures,[65] and the release of toxic chemicals.

(2) With 100 nuclear plants in operation, among the 15 million people living within 25 miles of a nuclear plant, two fatalities and 20 injuries are expected each year due to reactor accidents. In the same

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[64]The RSS was not the first time accident sequences were studied. In some cases work has been going on since 1947. But the RSS tied much of this research together and it now serves as something of an upper boundary on present understanding of reactor safety. Accordingly the discussion is organized around the points brought up in the RSS and this organization may appear to overemphasize the importance of the RSS.

[65]Several witnesses commented that in California, with its earthquake record, the public should be as concerned with the catastrophic rupture of a dam as they appear to be about catastrophic reactor accidents (e.g., Edward Teller, Transcript, Oct. 21,1975, p. 6; Wilson, Transcript, October 28, 1975, p. 6.)

population 560 would be expected to die in fires and 4200 in automobile accidents.[66]

(3) The worst possible reactor accident would produce 3300 fatalities, 45,000 early illnesses, and 14 billion dollars in property damage, and would require people to be relocated from a 290 square mile area and a 3200 square mile area decontaminated.[67] In the 10 to 40 year period following such an accident, cancers induced by the radioactive materials released would claim the lives of 1500 people per year, thyroid nodules requiring treatment would show up in 8000 people per year, and 170 children born each year, parents exposed in the accident would be affected with genetic disorders.[68] With 100 reactors operating the report says the chances of all this happening are one in 10 million per year.

(4) The most common accident involving the release of radioactive material has a one-half percent chance per year of occurring (with 100 reactors in operation). In this accident, the chances that even 1 person will be killed, injured, or given cancer are less than 100% -- conceivably no health problems could arise. Less than $100 million of property would be damaged and on the order of 50-60 acres of land would have to be decontaminated.[69]

In two previous exercises in 1957 and 1964,the AEC tried to estimate the maximum conceivable consequences of a reactor accident. The RSS results are in the same range as those in previous studies -- if anything, RSS is a little higher. The major advance of RSS was assigning probabilities and looking at less serious but more frequent accidents.

The critics of the Reactor Safety Study go right to the

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[66]Reactor Safety Study, Executive Summary, p. 9.

[67]Reactor Safety Study, p. 107.

[68]Reactor Safety Study, p. 111. The normal incidence for the same population would be 17,000 cancer deaths per year; 8000 thyroid nodules per year, and 8000 genetic disorders per year.

[69]Reactor Safety Study, p. 107.

methodology employed and claim that the numbers generated are meaningless. One witness stated that (1) RSS had used an incorrect and thoroughly discredited methodology, (2) the methodology was incorrectly applied in a number of instances, and (3) given the foregoing, the effort in the RSS was misdirected into a concerted attempt to generate low estimates of accident risk.[70]

RSS Methodology. RSS used a set of techniques previously employed by NASA and the Defense Department called "event trees" and "fault trees". Basically, the analyst using these techniques attempts to trace a sequence of events leading to an accident, specifying the components involved and the rate of failure of each. RSS uses this approach to combine the component failure rates and event chains with an estimate of the frequency of accidents. Critics claim that in analogous situations in the space program, the predicted accident frequencies turned out to be wide of the mark. For example, the Apollo 4th stage rocket engine had a predicted reliability of 0.9999 (1 failure per 10,000 missions). The highest reliability actually achieved by this engine after thousands of tests was only 0.96 (4 failures per 100 missions). The General Accounting Office also notes that in the space program where the cost of improved reliability was no hurdle, only 85% of the launches were successful; for the moon rockets (the Saturn V) the launch reliability was 92%[71] Therefore, the critics view the nuclear power plant system

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[70]Kamins, Transcript, Oct. 28, 1975, p. 95.

[71]Reactor Safety Study, Transcript, Oct. 28, 1975, p. 197.

reliability of 0.999999 predicted by the RSS as being completely at odds with comparable experience. The critics note that the inaccuracy of fault tree analysis in predicting absolute reliability was realized 10 years ago in the space program and the tool was relegated to tasks of identifying potential design weak points and making relative comparisons of reliability between two systems.[72] Critics contend there have been a number of subsequent techniques developed in the aerospace field for estimating absolute reliability which RSS does not even discuss. This contrasts with statements in the RSS that the "latest" aerospace methodologies are being used.

The major weaknesses of the event-tree/fault-tree approach pointed out by critics are:

(I) Not all accident modes can be identified. The analyst, unless omniscient, misses sequences of events which significantly reduce reliability. In the aerospace field, for new systems, the actual causes of failures often turned out to have been things completely overlooked.

(2) All relevant failure rates are not available. The reliability of each component in a system must be known with some precision in order for the fault trees to be meaningful in an absolute sense. RSS notes, however, that the data from nuclear reactors were not sufficient nor detailed enough. Consequently, data from analogous industrial situations was used. The critics note that the data from non-nuclear situations may not be applicable in the more demanding conditions in a nuclear reactor, leading to gross overestimates of system reliability since the uncertainty in the failure rate may in as much as a factor of 1000 or 10,000.[73]

(3) Component failure interdependencies are not included.

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[72]Kamins, Transcript, October 28, 1975, p. 197.

[73]Kamins, Transcript, October 28, 1975, p. 188.

RSS assumes the failure of one piece of equipment is independent of failures elsewhere. However, fragments from an explosion in one area may damage other pieces of equipment.

(4) Design deficiencies are not analyzed. In the Atlas ballistic missile program a large percentage of the test failures were due to design error not equipment malfunction.[74] RSS assumes no design problems; accidents occur only through equipment malfunction.

(5) Human error not adequately included. To the critics operator errors are probably the most likely cause of reactor accidents,[75] but the errors are hard to anticipate and quantify. RSS does consider human error and tries to estimate "human failure" rates based on experience elsewhere, but the critics maintain human errors are not so easily dealt with. They ask how you "quantify the risk of stupidity". Therefore, the RSS estimates of the probability of accidents may be misleading, since the probability of other (non-nuclear) accident situations in which human error plays a big role and with which we have direct experience are used for direct comparison.

In looking over the RSS,[76] the APS study concludes:

> "...we recognize that the event-tree and fault-tree approach can have merit in highlighting relative strengths and weaknesses of reactor systems, particularly through comparison of different sequences of reactor behavior. However, based on our experience with problems of this nature involving very low probabilities, we do not now have confidence in the presently calculated absolute values of the probabilities of the various branches..."[77]

In the face of their detractors, the authors of the RSS

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[74]Kamins, Transcript, October 28, 1975, pgs. 177-178.

[75]Primack, Transcript, October 28, 1975, p. 47.

[76]The APS study group did not attempt to critique the RSS since it was not available in time for their study, though they did choose to comment on the general methodology.

[77]APS Report, p. S-5.

maintain that the fault tree/event tree methodology is appropriate.[78] They also cite several letters in defense from NASA, the GAO and a British firm specializing in reliability techniques. The British firm notes that they have been able to predict failure rates within a factor of 4 of observed rates using fault trees in analysis of some 50 systems.[79] All the letters caution, however, that fault trees are good only where there is enough accurate data on individual component failure rates.

The RSS also points out that the low possibility of serious consequences is only due in part to the system failure rates estimated through fault trees. The low probability of adverse weather conditions (inversion layers, no strong winds) and a breeze carrying any radioactive plume over the most densely populated area around a reactor are equally significant factors. Therefore even if the fault tree analysis were off by a factor of 100, the probability of a large accident would increase only from one in a billion to one in ten million. But some have stated that under a similar setting, experts have disagreed by a factor of 10,000 on the probability of any one event.[80] Were this range of uncertainty to hold for the RSS, its results would become meaningless. They point to a statement

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[78]The RSS authors note that fault trees as conventionally applied do have deficiencies, but that they have attempted to eliminate these deficiencies by using event trees which work backwards from the accident to the sequences of events that could have caused it, rather than starting with a failure in one component and working through to see if an accident results.

[79]Reactor Safety Study, p. 187.

[80]Okrent, Transcript, October 29, p. 92.

made by Clifford Beck, Deputy Director for Regulation of the AEC in 1965 which contradicts the current official optimism in the RSS techniques:

> There is no objective quantitative means of assuring that all possible paths leading to catastrophe have been recognized and safeguarded or that safeguards will in every case function as intended when needed. ...There is not even in principle an objective and quantitative method of calculating the probability or improbability of accidents or the likelihood that hazards will or will not be realized.[81]

Other criticisms of RSS. After the draft RSS was released in August 1974, several organizations undertook extensive evaluations of it. Several of the criticisms they made led to changes in the final version. Several criticisms[82] still stand, though:

(1) Deliberate sabotage is not considered. The RSS authors reply that the probability of successful acts of sabotage cannot be estimated and that the consequences would not exceed the largest calculated for other accident events.[83] Therefore, consideration of sabotage would add nothing to the study. The critics feel unsatisfied by this response especially in light of the recent announcement by NRC that at 99 times since 1969 incidents of threats or violence were directed at licensed nuclear facilities[84] and two explosives charges were detonated in a reactor in Europe by saboteurs.[85]

(2) Treatment of earthquake risk flawed. The RSS extrapolates past earthquake experience to generate probabilities of serious seismic damage. According to

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[81]Transcript, December 10, 1975, p. 52

[82]The criticisms are reprinted along with a response in the Reactor Safety Study itself.

[83]Reactor Safety Study, p. 172.

[84]Sacramento Bee, March 19, 1976, p. A13.

[85]Nucleonics Week, May 8, 1975, p. 6.

the critics, too little is known about previous earthquakes, because of lack of instrumentation to make this extrapolation valid. They point to the comments of geologists and seismologists that every new large earthquake has been surprising in terms of what was expected.[86]

(3) Evacuation estimates unrealistic. Critics allege the fatalities and injuries stemming from a reactor accident are low in the RSS because an unrealistically rapid and efficient evacuation was assumed. The RSS authors counter that their estimates were based on an examination of actual evacuation experience under similar conditions. Furthermore, they assure evacuation of only a small population 25 miles or less from the reactor in the direction of the passing cloud. The evacuation is done to minimize early exposure and prevent substantial doses to individuals near the reactor. The remainder of the affected population is not assumed to be evacuated.[87]

(4) Only LWR's of the present design, conventionally sited were considered. Critics note that reactor concepts other than current vintage BWR's and PWR's sited on land were not included in the RSS. They contend that proposed offshore, floating nuclear plants, for example, pose a much greater risk. The possibility that other reactor designs, such as the HTGR or the Canadian Candu reactor, present a much lower risk than LWR's is also overlooked, according to the critics.[88] The authors of the RSS reply that data on these other systems was even less adequate than for LWR's and that the BWR and PWR would be the backbone of the reactor business for some time to come.

(5) Steam explosion analysis slighted. While the uranium in a reactor does not contain enough fissionable material to create an atomic explosion, recent research indicates that molten fuel dropping into water could

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[86]Kamins, Transcript, October 28, 1975, p. 93.

[87]Reactor Safety Study, Appendix VI, pgs. 11-4 to 11-6.

[88]Primack, Transcript, October 28, 1975, p. 142, 159.

release the equivalent of 19 tons of TNT of energy in a steam explosion within the pressure vessel. If only 20% of the core melted, the resulting force equivalent to 3.8 tons of detonating TNT might still be enough to wrench the pressure vessel apart.[89] The RSS admits there are no definitive experiments on steam explosions to evaluate what the hazard really is, or how likely an explosive interaction between molten fuel and the pool of water at the bottom of a reactor would be. Nevertheless, the RSS predicts that in only one in ten fuel melt accidents will an explosive interaction occur, and in only one in ten of such cases will the explosion yield enough energy to breach the containment and release a significant amount of radioactive material. In the absence of any experimental verification of the probabilities used in the RSS, critics wonder if the chances aren't really quite a bit higher. The RSS authors believe they have been suitably conservative and note that initial experiments are now underway.

Several serious reactor malfunctions, but safety record unblemished. There has never been an accident involving the excessive release of radioactive materials at any of the 55 nuclear power plants now in operation in the U.S. However, the critics point to a number of unusual occurrences and unexpected problems as evidence that the operation of these plants has not been smooth and could have led to serious accidents:[90]

--On June 5, 1970, the Dresden 2 BWR near Chicago suffered a partial loss of coolant when the pressure control system malfunctioned. In trying to correct the problem the water level in the reactor started to get too high. The emergency core cooling system was called upon, but the high pressure portion was shut down

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[89] Kevin P. Shea, "An Explosive Reactor Possibility," Environment 18:6-11 (January/February 1976).

[90] The Atomic Industrial Forum has labelled this the attitude of the "what if" critics.

for repairs following earlier damage and the low pressure system was inhibited because of the 350 psi pressure in the reactor.[91]

--During a routine check at a power reactor, abnormal radioactivity was observed in the plant drinking fountains. The contamination was found to have arisen from an inappropriate cross-connection between a 3,000 gallon radioactive waste tank and the water system.[92]

--Repeatedly, important valves have failed to operate properly. In one case, an entire core spray system was found inoperative because check valves had been jammed during assembly.[93] Elsewhere 63 out of 191 containment isolation valves failed to operate when tested.[94] Their failure apparently resulted from rust, oil, and water present due to lack of preventative maintenance. Valve failures outside the nuclear portion of plants have resulted in the deaths of two technicians; other valve failures have led to the uncovering of a reactor core.[95]

--Small hairline cracks were found in the four-inch bypass pipes in the primary coolant recirculation loop at the Dresden 2 plant. The AEC then told utilities with similar BWR's to inspect for bypass line cracks in September 1974, and similar cracks were found on four additional reactors. Later on January 28, 1975 small cracks in two 10-inch diameter core spray pipes were found on the Dresden-2 reactor. The new NRC then gave the utilities 20 days to inspect for cracks in this new location. No cracks were revealed at other installations.[96]

--The Millstone Point reactor scrammed twice in three days, once when an automatic valve failed in the feed

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[91] Nuclear Safety, September/October 1971, Vol. 12, No. 5.

[92] The AEC report on this incident dryly adds: "The coupling of a contaminated water system with a potable water system is considered poor practice in general". (AEC, Recent Operating Experiences (ROE), 69-10).

[93] ROE 69-8.

[94] ROE 71-72.

[95] ROE 71-2.

[96] U.S. Nuclear Regulatory Commission, Report to the Congress on Abnormal Occurrences, January-June 1975 (hereinafter cited as "Abnormal Occurrence Report", p. A-15.

water line and the water level in the reactor dropped, and again when a defective pressure regulator allowed the pressure to build up in the reactor and increased reactivity in the core. The valve malfunction was attributed to excessive wear due to vibration. The pressure regulator failed because of a poor solder connection.[97]

--The Vermont Yankee BWR accidently went critical during a refueling, with the reactor vessel head off and the containment building open. A scram occurred automatically.[98]

--Shrinkage or "densification" of fuel occurred in a number of pressurized water reactors, leading to collapsing of the fuel rods, partial blockage of coolant flow channels, and localized hot spots in the core. The AEC temporarily reduced the permissible level of power generation of a number of plants by 5 to 20 percent, until fuel rods could be replaced. AEC and Westinghouse have said that the difficulties of the densification have been eliminated through design changes.[99]

--Damage to fuel channel boxes used for directing coolant flow around the fuel rods was caused by excessive vibration of instrumentation tubes against the channel boxes. The situation could have led to overheating and damage of the fuel rods, or blockage of coolant flow.[100]

--A 4- by 6-inch connector in the feedwater line at the Quad Cities nuclear power plant broke, and 8,500 gallons of reactor cooling water escaped from the severed line. Flow-induced vibrations were thought to have caused the problem.[101]

--All three shaft seals on one of three main coolant pumps in a PWR failed, resulting in an unisolatable leak from the reactor coolant system to the containment building.

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[97] Nuclear Safety, Vol. 12, No. 6, p. 619, Nov.-Dec. 1971.

[98] Nuclear Safety, Vol. 15, No. 2 (March-April 1974) pgs. 210-211.

[99] The Nuclear Power Alternative, p. 62.

[100] Abnormal Occurrence Report, p. A-19.

[101] Nuclear Safety, Vol. 17, No. 1 (Jan.-Feb. 1976), pgs. 107-108.

Approximately 132,500 gallons of radioactive primary coolant water leaked out and the normal reactor coolant water makeup system was unable to maintain the coolant level. The leak greatly exceeded the postulated leakage for pump seals of that design. The reactor power was quickly reduced from 100% to 36% and the leaking pump was shut down. The reactor shortly thereafter completely shutdown automatically, a safety injection system provided reactor coolant makeup, and the fuel was adequately cooled.[102]

--In probably the most talked-about accident, a worker using a candle flame to check for air leaks in cable penetrations through a containment wall set fire to foam packing at the Browns Ferry-1 and -2 nuclear plants in Alabama, March 22, 1975. The fire spread to cables in nearby cable trays, burning for seven hours and damaging 2,000 electrical cables. Both units lost power but were eventually shut down. The emergency core cooling system was knocked out, along with several other safety features, the Unit 1 water level dropped at one time to 48 inches above the core (200 inches is normal) and the pressure climbed rapidly at another time. The control room was full of smoke and the operators were wearing air packs. The control room also lost its phones and public address system to the rest of the plant, making it difficult to dispatch men to open and close valves manually that no longer could be operated from the control room. Finally the fire was brought under control after several unsuccessful attempts to use chemical extinguishers. Only minor injuries to plant personnel resulted.[103]

Since no member of the public was exposed to excessive radiation as a result of these incidents, nuclear power proponents look on these occurrences as vindication of the adequacy of the safeguards and conservative design of modern plants. The critics are not equally impressed. They indicate that these errors and malfunctions demonstrate an inability to construct and operate plants with the degree of perfection required. The proponents admit that occurrences such as these confirm human

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[102]Abnormal Occurrence Report, p. A-7.

[103]Abnormal Occurrence Report, p. A-4.

fallibility, but contend that through such experiences, corrections can be made and designs improved. The critics wonder when one of these "incidents" will get out of hand.

The critics testified that these unexpected problems cast a pall over the validity of the Reactor Safety Study. They point to the number of times a breakdown was caused by improper installation of equipment, inadequate quality assurance,[104] defective components, design errors,[105] and outright goofs, compared to the RSS assumptions of essentially perfect operation until a component failed, and of perfect design and construction. The critics do not necessarily contend that the use of nuclear power is inherently unsafe. Some do point out that they believe nuclear power could be made acceptably safe. However, they do not feel present U.S. programs will result in adequate protection.[106]

In this regard they see the RSS as instilling a false sense of security in present systems and present approaches.[107]

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[104]The NRC blamed inadequate quality assurance by the utility as a partial cause of the Browns Ferry Accident (Nucleonics Week, March 4, 1976, p. 4). Recently a nuclear industry engineer quit on grounds of conscience, citing sloppy quality assurance on critical safety items (Nucleonics Week, March 11, 1976, p. 4).

[105]As an example, in one incident the discharge from a safety valve impinged on the lifting levers of two other safety valves, cocking them open (ROE-71-72).

[106]Ford, Transcript, October 21, p. 65; Hocevar, Transcript, October 21, p. 47.

[107]Ralph Nader testified that in his opinion the RSS was "the centerpiece in the phony public relations effort by the Federal Government" (Transcript, December 2, p. 11).

They point to the annual letters from the AEC's independent Advisory Committee on Reactor Safeguards listing generic unresolved safety issues. In 1975 the ACRS listed 27 safety items as still unresolved, including pressure buildup in the containment structure following a LOCA, rupture of high pressure lines outside the containment building preventing operation of critical safety components, stress corrosion cracking in BWR piping, common mode failures, and pressure vessel failure from post-LOCA thermal shock. The critics believe the issues raised by the ACRS should be dealt with before more reactors are built. The NRC however takes the position that the ACRS items are important areas for more studies but they are not crucial for the safe operation of nuclear power plants.[108] NRC and ERDA contend that through a vigorous safety research program, improvements can continually be made and any problems which require modification of existing facilities can be handled without too much inconvenience. Critics argue that the present reactor safety research program will not in fact provide the studies which are needed.

The American Physical Society Study, for example, reaches the conclusion that the research program presently planned by ERDA--the loss-of-fluid-test and the power burst tests, specifically--give no assurance of actually being able to resolve the

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[108]Rusche, Transcript, October 22, 1975, p. 72.

serious questions which have been raised about reactor safety.[109] The uncertainty is the result of the difficulties encountered in extrapolating the results from scale models which may not be entirely accurate mimics of large commercial power reactors. APS recommends that alternative emergency core cooling systems be designed and tested, so that we do not rely exclusively upon present ECCS concepts which are in dispute.

Furthermore, the APS study recommends that much greater effort go into (1) improving reactor containment, (2) mitigating the consequences of a large release of radioactive material, and (3) learning how to clean up afterward. The APS report mentions underground siting and the design of a "core catcher" to prevent melt-through by the core as areas for serious re-examination. Undergrounding, as also advocated by Dr. Edward Teller, is also suggested as a means for providing an extra level of safety. Berm containment, a concept originally advocated by the Oak Ridge National Laboratory, involving the placement of power plant components in a scooped out hole and backfilling over all the structures with the removed dirt, is another option which provides much of the release control advantages of undergrounding, but more cheaply. Examples of possibilities for mitigation of reactor accident effects include preparation of serious evacuation plans, and distribution of iodine pills to block uptake of radioactive iodine by the thyroid. At present only about $1 million is allocated to these tasks out of a total reactor safety research budget of roughly $70 million; almost all of

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[109] APS Report, p. S-6.

the money is presently going to studies of ECCS performance.[110]

Beyond possible modifications to existing reactor designs, other completely different reactor designs may be inherently safer than those we use now, some critics note. The High-Temperature Gas-Cooled Reactor (such as is being used at the Fort St. Vrain nuclear power plant) offers some advantages because it does not require elaborate coolant piping systems. Unfortunately, General Atomic, the makers of the HTGR, is no longer in the reactor business. The other reactor most often mentioned is the canadian CANDU reactor. The CANDU uses natural, unenriched uranium and heavy water.[111] Its major advantage in terms of safety is that it does not use a massive pressure vessel with a small number of coolant lines, but instead incorporates hundreds of pressure tubes within which are placed the fuel bundles. Complete loss of coolant from a single break becomes practically impossible. The CANDU is also attractive because it can be adapted to a thorium breeding cycle that will not have some of the safety implications of the U.S. liquid-metal cooled fast breeder reactor.

Proponents do not feel the safety situation is so bleak as to warrant these major changes. Nor do they believe other

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[110] Primack, Transcript, October 28, 1975, p. 143.

[111] Heavy water occurs naturally in all water but is rare. Separating it out involves a technical process which is energy consumptive.

reactor designs[112] or siting concepts offer significant safety advantages.

2. URANIUM SUPPLY AND THE BREEDER REACTOR

> Official government estimates of domestic uranium supply indicate there will not be enough to fuel reactors beyond 1990-1995. The uranium shortage is the rationale given for developing the fuel-producing "breeder" reactor. Critics are worried the breeder may be more accident-prone than conventional reactors and oppose its development. Some industry spokesmen believe the uranium supply is not so tight and the breeder not necessary, but opinion is divided.

Official estimates of the amounts of raw uranium available in this country indicate that supplies are insufficient to support projected growth in the use of nuclear power plants beyond about 1990-1995.[113] Figures such as these have been used by ERDA as the rationale for the breeder reactor program--using the extra fuel from breeders to fuel conventional reactors.[114]

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[112]Dr. Teller believes in part the alleged safety advantages of the CANDU are the result of the briefer safety analysis done by the Canadians. He notes that U.S. reactor safety analyses are four feet high on average; the Canadian reports are 4 inches high. Subjected to the same level of scrutiny, the CANDU reactor may be found to have safety complications similar to the U.S. light water reactors (Transcript, October 21, p. 15). A GE witness also commented the CANDU reactor is not subject to the same safety criteria as U.S. reactors (Bray, Transcript, October 21, p. 109). However, ERDA is now considering licensing CANDU reactors in this country because they do not need enriched fuel and can use uranium more conservatively (Nucleonics Week, August 7, 1975, p. 3).

[113]The Nuclear Fuel Cycle, p. viii.

[114]"While present day [light water] reactors can provide a vital contribution to meeting the Nation's electrical energy needs over the short term, the breeder reactor is necessary if fission energy is to contribute to the nation's long term needs." (Transcript, November 18, 1975, p. 22).

Critics argue that the breeder reactor involves safety problems much more serious than those of light water reactors. In an LWR, when the coolant is lost the nuclear chain reaction ceases. In the LMFBR, the core if deprived of liquid sodium cooling, could potentially melt and reorganize itself into a critical mass continuing the reaction.[115] No analysis of the probability and consequences of LMFBR meltdown, (such as the RSS) has been done.[116] Some critics are particularly worried about the consequences of LMFBR accidents because of the extremely toxic plutonium produced and used in the reactors. They are concerned not only about catastrophic reactor accidents dispersing plutonium but also about transportation accidents involving LMFBR fuel and about guerilla groups stealing enough plutonium to make a crude bomb.

Proponents point out that these safety questions are being dealt with as the federal breeder program progresses. The Safety Experiment Research Facility is proposed to be operational in the mid-1980's and will provide data on fuel behavior under loss of coolant conditions. Other safety questions (sodium fires, scram reliability, channel blockage, etc.) are also under active investigation.[117]

The nuclear industry does not believe the supply of uranium

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[115] U.S. General Accounting Office, The Liquid Metal Fast Breeder Reactor: Promises and Uncertainties, B-164105, July 31, 1975, p. 66 (hereinafter cited as GAO LMFBR Report).

[116] The nation's first commercial scale fast breeder reactor, the Enrico Fermi power plant outside Detroit, suffered a partial core meltdown in 1966 and has since been abandoned.

[117] GAO LMFBR Report, pgs. 108-113.

is so tight. They point out that the ERDA figures assume a maximum price of $30 per pound for milled uranium. At higher prices, leaner deposits can be worked. Three new studies (done by the Electric Power Research Institute, MIT, and Battelle Northwest Labs) conclude that at a price of $100 a pound, up to 10 times more uranium is available in the U.S.[118] Of course, more expensive uranium means higher cost electricity from power reactors. Proponents hold that fuel costs for nuclear plants are so minor compared to capital costs that large increases in fuel costs translate into very small jumps in the cost of electricity.[119] The Federal Government has begun a detailed evaluation of domestic uranium resources and has decided to remove restrictions on importation of foreign uranium.[120] This latter decision has raised questions about the role of nuclear power in energy independence. If domestic users resort to foreign uranium imports (for either price or supply reasons), the U.S. may have only traded oil dependence for uranium dependence.[121]

Faced with the uranium situation, critics have asked: If the uranium supply is so short that we must commit ourselves to a potentially even more dangerous breeder technology, then why begin using conventional reactors at all? And if there is much more uranium available, why are we devoting so much

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[118] Nucleonics Week, October 24, 1974.

[119] Transcript, November 4, 1975, pgs. 28-29.

[120] To promote a domestic industry the government has not allowed the burning of foreign uranium in domestic reactors.

[121] Transcript, November 4, 1975, p. 71.

government money to develop the breeder? Some traditional supporters of the nuclear industry have begun to ask this latter question in addition to the usual critics. Dr. Edward Teller now doubts the breeder is needed[122] and an analysis done by the American Enterprise Institute concludes the LMFBR will be uneconomic.[123]

The division of opinion on the breeder runs deep. ERDA witnesses did not agree that the LWR program of necessity leads to the breeder, cautioning that "the nation is not committed to the large scale deployment of commercial breeder plants."[124] At the same time other proponents are convinced breeders are necessary and will be economical,[125] a position ERDA was not willing to take.[126]

3. REACTOR RELIABILITY

> If nuclear plants break down more frequently than coal or oil-fired power plants, they lose some of their economic edge. Critics claim the performance of nuclear plants is so poor that coal-fired plants make cheaper power. Proponents don't believe nuclear plants are unusually troublesome, have confidence reliability will improve, and feel even if nuclear plants had a poor record they would still be the cheapest power source.

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[122] San Diego Union, March 3, 1975, p. B-1.

[123] Brian G. Chow, The Liquid Metal Fast Breeder Reactor: An Economic Analysis, American Enterprise Institute for Public Policy Research, December, 1975.

[124] Transcript, November 18, 1975, p. 23.

[125] Transcript, October 15, 1975, p. 79.

[126] "The breeder reactor, economically speaking, is just going to come a little bit too late" (Robert Thorne, ERDA, Transcript, October 15, 1975, p. 57.).

Challenging the claim that nuclear power will be low cost, critics have charged that large reactors are undependable, plagued with frequent and sometimes lengthy shutdowns for repairs.[126] Because of high fixed costs, outages of nuclear plants are quickly reflected in higher average power costs (taxes, interest, and depreciation must be paid whether the plant is operating or not). The measure of plant reliability most often used is the "capacity factor.[127] Unit costs of electricity decline as the capacity factor goes up.

Coal plants more reliable? Traditionally, economic comparisons between types of power plants assumed identical capacity factors for all plants (generally 80%). Critics now claim that nuclear plants perform significantly more poorly than their major alternative--coal-fired plants--and the poor showing erases any cost advantage nuclear plants may have. A witness for the non-profit Council on Economic Priorities testified that for plants now in operation over 600 MW in size, coal plants have achieved a 58% capacity factor verses 49% for nuclear.[128] These results are similar to those reported by the Federal Energy Administration in March, 1975: 59.7% for coal, 50.0% for

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[126]While it is only one case, the 960 MW Rancho Seco nuclear power plant near Sacramento has been out of operation for all but 14 weeks since it started commercial operation one year ago. (UPI wire story, April 28, 1976). In contrast though, the 450 MW San Onofre-1 reactor recently achieved an 86.1% capacity factor in 1975. (Nucleonics Week, January 29, 1976.)

[127]The capacity factor is the ratio of the average output of the plant to the plants maximum output capacity.

[128]Transcript, December 3, 1975, p. 222.

nuclear.[129] Again data from the Atomic Industrial Forum show the opposite trend: coal at 54.8% capacity factor, nuclear at 64.4%.[130] One explanation: the AIF data is for all sizes of plants. Small nuclear plants (less than 600 MW) have been consistently more reliable than the large new plants. Nuclear plants over 800 MW through September, 1975 averaged 49% capacity factor, according to one witness.[131] This data is relevant because 97% of the reactors now under construction are 800MW or larger. ERDA witnesses upon questioning agreed reliability problems are serious and merit more study, but maintained that capacity factors were similar for all types of plants--about 60%.[132]

Capacity factor affects competitiveness of coal and nuclear. Since nuclear plants involve a significantly greater capital cost than do coal-fired plants, they are particularly cost-sensitive to changes in capacity factory. If a plant breaks down, the operator tries to cut his costs by reducing his variable costs--fuel usually. This is not easily done for a nuclear plant (it's fueled only once a year anyway) but for the coal plant, cutting back coal deliveries is easy. As capacity factor drops then, the average cost of power climbs much more steeply for a nuclear plant than a coal-fired plant. A staff calculation for the committee indicated, using industry assumptions on capital

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[129]Transcript, December 3, 1975, p. 210.

[130]Atomic Industrial Forum, "Nuclear Info", No. 13, March 1976.

[131]Transcript, December 3, 1975, p. 222.

[132]Transcript, October 15, 1975, p. 65.

costs, operating costs, that a nuclear plant in the state produced power slightly less costly than that from a coal-fired plant in Utah, assuming both achieved a 65% capacity factor (26.2 mills per kilowatt hour for nuclear, 27.1 mills/kwh for coal). If the nuclear plant managed only a 55% capacity factor, while the coal plant still achieved 65%, the coal plant could potentially be cheaper (31.0 mills/kwh nuclear vs. 27.1 mills/kwh coal).[133] The problem with any calculation such as this is the sensitivity of the result to the initial assumptions. Assumptions can be made which make nuclear plants the economic choice for California down to 40% capacity factor.

Will reliability improve? Proponents see this argument as based on scanty information. They believe reliability will improve with time and experience. New plants are being designed and built with the lessons of the pioneering units in mind and individual plants, generally speaking, achieve better performance after an initial "shakedown" period.[134] But critics see reasons to dispute these claims. David Comey, a Chicago lawyer for Business and Professional People in the Public Interest, believes capacity factor may decline with the age of the plant. He notes that on some recent repairs, radioactive "crud" had built up in the primary system so that workers could not remain on the job very long.[135] Comey believes this will increase the

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[133]Transcript, October 14, 1975, pgs. 24, 26, 27.

[134]Atomic Industrial Forum, "Reliability of Nuclear Power", Background Info, March 1976.

[135]Transcript, December 3, 1975, p. 116.

time it takes to repair a nuclear plant. Alternatively, though more workers could be used.

4. SPENT FUEL TRANSPORTATION ACCIDENTS

> Spent fuel from reactors contains a large amount of radioactive material. During shipment of this fuel to reprocessing plants, truck or train accidents might break open the fuel and release its radioactive contents. To prevent this, the fuel is shipped inside massive casks. Official estimates indicate only one radiation-caused fatality per 100 years from nationwide shipment accidents. Critics believe the risks are underestimated and certain of their claims are supported by reports of other government agencies. The NRC notes the unblemished safety record and concludes their requirements are adequate.

The nuclear fuel from reactors must be periodically removed and replaced with fresh fuel to maintain the characteristics needed for the chain reaction. The spent fuel is temporarily stored at the power plant to allow much of the short-lived radioactive fission products to decay ("cool-down" period). The spent fuel is supposed to be transported then to a reprocessing plant to recover the remaining unused fuel and to remove the highly radioactive waste products for eventual disposal. The spent fuel, because it is still intensely radioactive, is transported inside heavy casks (subject to "stringent" NRC standards) that provide shielding and containment. Because of the weight of these casks (20 to 80 tons each) only one ton of spent fuel can be carried per truck or 3.2 tons per rail car.

If all the nuclear plants now planned by the utilities are

built, the amount of spent fuel transported in the state each year will rise from 105 tons in 1975 to over 1000 tons in 1995, or about 275,000 vehicle miles of spent fuel movement.[136] ERDA witnesses testified that nationwide there may be as many as one transportation accident per month by the year 2000, but only one in 300 accidents would release radioactive material, and the release could result in only one fatality per 100 years.[137]

Critics contend the risks of fuel transportation have been underestimated. The government assumptions on dispersal of radioactive cesium have been challenged.[138] Others believe special combination hazards should be considered, e.g. high temperature combustion of organic chemicals or munitions explosions on trains also carrying spent fuel. The General Accounting Office found that cask failure in an accident may be more probable than assumed because (a) review staffs did not have sufficient expertise (according to AEC standards) to analyze cask designs and in fact had approved defective casks, (b) cask constructors did not have sufficient quality control programs, and (c) reinspections of reusable casks were only cursory.[139]

The NRC, which is responsible for ensuring the safety of

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[136]Based on information in The Nuclear Industry 1974, WASH 1174-74, U.S. Atomic Energy Commission.

[137]Transcript, November 4, 1975, p. 8.

[138]Marc Ross, "The Possibility of Release of Cesium in a Spent-Fuel Transportation Accident," Physics Department, University of Michigan, January 1974.

[139]U.S. General Accounting Office, "Opportunities for AEC to Improve its Procedure for Making Sure that Containers Used for Transporting Radioactive Materials are Safe," Report B-164105, 1973.

waste fuel shipments, in response to these and other criticisms, points to their good safety record and their continuing improvements in standards and enforcement. In thirty years of fuel shipment "there has never been a release of contents or a significant increase of radiation levels from an irradiated fuel cask in transportation."[140] For the future, NRC will continue to re-examine its standards and study ways "to further reduce the already small probabilities of accidents and incidents."[141]

5. PERMANENT NUCLEAR WASTE DISPOSAL

> The byproducts of the fission process eventually decay away, but for some elements this takes a long time. For most elements there is no way to hasten the decay process. These elements must then be isolated for periods of 1000 years or more until they can be safely released. ERDA plans to solidify wastes and bury them in stable geologic formations. Critics believe waste disposal requires an unattainable degree of perfection and social and geologic stability. Therefore the chances of premature waste release pose risks to the public for hundreds of years into the future. ERDA will not be operating test disposal sites until the 1980's and critics object we are creating wastes with no guarantee we will be able to safely dispose of them. Nuclear proponents believe the hazards are exaggerated and even if a disposal site were disturbed, wastes would escape very slowly.

At least 1000 year isolation required. An average LWR produces 7 metric tons of high level waste each year. These wastes contain both short-lived and long-lived radioisotopes. If

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[140] Transcript, November 4, 1975, p. 142.

[141] Ibid., p. 146.

solidified, the wastes accumulated by the year 2000 (if all projected nuclear capacity is built) would occupy a volume of about 500,000 cubic feet.[142] These wastes decay eventually into stable, nonradioactive elements. In the process, heat is given off. The half-million cubic feet of waste accumulated by 2000 would be giving off 660 megawatts of heat.[143] The wastes contain so much radioactive material, they cannot simply be diluted away without problems. Instead they must be isolated until they have decayed naturally to insignificant levels of radioactivity. Ten years after removal from the reactor the wastes decline 1000-fold in radioactivity. But because there are long-lived products in the wastes, a further 1000-fold reduction requires 1000 years.[144] After the first 10 years, the wastes are dominated by radioactive strontium (a relative of calcium) and cesium (a relative of potassium), which decay to insignificant levels in the next 1000 years. Beyond this period the waste is dominated by very slowly decaying "actinides", a series of very toxic elements which includes plutonium. Because of these actinides, the waste remains at nearly constant radioactivity[145] virtually in perpetuity (i.e. for longer than

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[142] U.S. Atomic Energy Commission, High-Level Radioactive Waste Management Alternatives, WASH-1297, 1974, p. A-9 (hereinafter cited as WASH-1297).

[143] Ibid.

[144] S. Kubo and D. Rose, "Disposal of Nuclear Wastes," Science 182:118 (1973).

[145] The level is one million times less than when the wastes were first withdrawn from the reactor, though. One article estimates the hazard as of the same order as pitchblende--a natural uranium ore [A. M. Weinberg, "Social Institutions & Nuclear Energy," Science 177:27-34 (1972), reprinted in Transcript, Nov. 4, p.236-243)

10 million years).[146] The task then is to devise methods to isolate nuclear wastes for at least 1000 years and, for breeder wastes which contain more actinides, over a million years.

Critics believe disposal depends on unattainable degree of perfection. Critics doubt the degree of permanence in either the earth's geology or social institutions required for safe waste disposal can be achieved. They fear that at some point before the wastes have decayed to a harmless point, they could escape and create a hazard either through mischief or a variety of accidents. ERDA agreed that to make sure the wastes remained sequestered,even the most highly developed disposal method, while requiring no planned maintenance, would involve "nominal surveillance".[147] Critics question the wisdom of pledging 1000 years of surveillance.

In support of their view that human fallibility makes a satisfactory solution of the waste disposal problem unlikely, critics cite the experience in handling wastes left from the weapons program. At the Hanford Reservation at least sixteen leaks in waste storage tanks have occurred in the last 15 years, allowing 350,000 gallons of high level waste to seep into the soil.[148] In defense, ERDA said tanks of the design that leaked are no longer used for new construction, and there

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[146]Kubo & Rose, op. cit.

[147]Transcript, November 4, 1975, p. 9.

[148]U.S. Atomic Energy Commission, "Report on Investigation of 106T Tank Leak at Hanford Reservation, Washington," 1973.

have been no leaks from tanks of the newer design.[149]

ERDA plans emphasize waste solidification and disposal in geological formations. For long-term disposal, ERDA intends to solidify the liquid wastes, such as those stored at Hanford, in order to reduce the volume and to immobilize the radioactive elements. Several solidification techniques are under development. One technique (calcining) has been in routine use for years, but another ("vitrification" or adding wastes to a molten glass and letting it harden to a ceramic-like material) is generally considered superior. Vitrification is the technique many nuclear proponents believe will be the ultimate solution. ERDA witnesses testified the technique works in the laboratory but is yet to be scaled up to a commercial process, and its long-term stability has not been ascertained.[150]

For disposal of the solidified waste, ERDA plans seem to emphasize placement in stable geologic strata--deep granite caverns, deep wells, salt beds--although rocketing the material into space and dumping into the deep ocean have also been studied.[151] A scheme to separate out the actinides, placing them back into a reactor's high neutron flux and transmuting or fissioning them to less troublesome elements, was considered for a time but seems to be discarded now. The process required expensive separation techniques, the actinides needed to be recycled repeatedly, potentially producing even more

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[149]Transcript, November 4, 1975, p. 86.

[150]Transcript, November 4, 1975, pgs. 30-31.

[151]WASH-1297.

ancillary wastes, and there was little agreement that the long-term hazard was reduced.[152] ERDA estimated in 1974, though, that 25 to 30 years would be required before any of the permanent disposal methods could be brought up to full scale operation.[153]

Proponents believe hazards exaggerated. Proponents point out that enough arsenic is imported into this country each year to kill five billion people, yet it is handled safely.[154] The pertinent question for waste disposal is how much of the lethal material is likely to escape and cause damage. While there has been great emphasis on choosing a geologic burial site that would prevent water/waste contact, one estimate suggests the hazard from such contact would be minimal since the water found at great depths only very slowly finds its way into the environment and very little radioactive material would leach out of vitrified waste.[155] This view has been characterized as based on "legitimately debatable" and untested assumptions.[156] But if the calculations were borne out by further study, the preoccupation with absolute, perpetual containment could be unnecessary.

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[152] A. B. Lovins and J. H. Price, Non-Nuclear Futures (Ballinger: Cambridge, 1975) p. 34.

[153] WASH-1297.

[154] Bernard Cohen, "Environmental Hazards in Radioactive Waste Disposal," letter appearing in Physics Today, January 1976.

[155] Ibid.

[156] Nucleonics Week, August 7, 1975.

6. SAFEGUARDING PLUTONIUM FROM THEFT

Making an atomic bomb requires raw material with a high concentration of fissionable material. Present reactor fuels are not suitable for this purpose, but shortly plutonium produced in these reactors or in breeder reactors may be in transit around the country in the form of almost pure fissionable material. Critics are concerned that terrorists, or foreign governments that do not now have nuclear weapons, may steal plutonium and make a crude bomb. Even if a bomb were not made, critics allege the thieves could threaten to contaminate populated areas with the highly toxic plutonium. The NRC feels the chances of an amateur successfully making an atom bomb are slim and the safety risks to the amateur high. But studies done for NRC indicate the motivation exists among organized crime to steal bomb-grade material for the right price.

The NRC has imposed protection requirements on bomb grade fuels including physical barriers, security checks, and armed guards. Critics are skeptical of the effectiveness of the safeguards since other well-guarded, valuable materials are routinely stolen. The nuclear industry is confident tight enough protection can be developed--this worries critics who believe safeguards tight enough to be effective might threaten the civil liberties of the general public. Proponents believe these fears are exaggerated.

Currently, operating LWRs are producing approximately 150 kilograms of plutonium[157] each year for every 1000 MW of generating capacity. By 1990, the amount of plutonium produced

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[157]The plutonium is produced by absorption of neutrons into the non-fissionable U-238 which makes up 97% of the uranium fuel in a light water reactor. The difference between a LWR and a breeder is that the breeder is designed to make plutonium production so much more efficient than it is in a LWR, that more fissionable plutonium fuel is produced than is consumed in the reactor.

annually will approach 60,000 kilograms.[158] With widespread use of the breeder reactor, the amount of plutonium in the fuel cycle is estimated to be 5,000 metric tons (5,000,000 kilograms).[159]

Critics are concerned about this level of plutonium use because:

(1) Terrorists could steal 10-20 kg of plutonium and make a crude atomic bomb or threaten to contaminate densely populated areas (plutonium is highly toxic and cancer-causing).

(2) Foreign governments currently with no nuclear military capability could illictly obtain enough plutonium to construct bombs.

(3) The safeguards necessary to prevent terrorists' nuclear activities may seriously erode civil liberties.

At the present time, the plutonium that is being produced does not pose a great problem because it is contained in the accumulating unreprocessed spent fuel rods, mixed with hazardous fission products. When and if a decision is made to proceed with

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[158] Transcript, November 18, 1975, p. 20.

[159] Ibid., p. 23. It is technically possible to build a breeder reactor which does not produce plutonium, however. Fissionable uranium-233 can be bred from fertile thorium-232 in the same way Pu-239 is made from U-238. The safeguards problem could be less serious if the U-233 from the thorium blanket were immediately blended with other U-235 and U-238, diluting the amount of fissionable material below the point where it could be used in a bomb. This would only reduce the safeguards problem not eliminate it, because some plutonium would still be produced. Some question exists as to whether a thorium breeder is worth the trouble. Dr. Edward Teller is one, though, who favors the thorium breeder over the plutonium breeder (Transcript, October 21, 1975, p. 17.).

fuel rod reprocessing and/or plutonium recycling,[160] the plutonium will be recovered and be vulnerable to theft.

These concerns have been officially acknowledged by the NRC:

> Since only a few kilograms of plutonium, uranium-233, or uranium-235 are enough for a nuclear explosive device, and the amount of such materials in commercial activities is projected to increase to many thousands of kilograms in the coming decade, there exists considerable cause for concern. Even if one were to discount the possibility of a terrorist constructing a home-made bomb, the high radiotoxicity of plutonium allows it to be used in quantities of less than one kilogram as a contaminant or health threat.[161]

Is a homemade atom bomb possible? Building atom bombs has traditionally been a technologically sophisticated enterprise. But with the declassification of literature on the first atomic weapons and the availability of the basic bomb material, some believe the enterprise has been simplified: "The design and

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[160]The NRC has delayed licensing reprocessing plants until it reviews the environmental impacts and safeguard alternatives for the so called "plutonium economy" in which plutonium produced in commercial reactors is recovered from the fuel rods and recycled as 'mixed oxide' (plutonium/uranium) fuel into other reactors. (thus conserving uranium resources by reducing uranium demand by 15-20%). While in March, 1975 it appeared the resolution was "several years off" (Nuclear Fuel Cycle), in Nov. 1975 the NRC indicated they expect to reach an interim decision in early 1977 on uranium recycling, but putting off the decision on wide scale use of plutonium (Tr., Nov. 18, p. 2) and license recycling facilities on an interim basis pending the final decision (Tr., Nov. 19, p. 50). Theodore Taylor (a highly respected safeguards critic) expressing concern regarding the schedule advance stated, "I don't know what's changed that would give rise to a possibility of shortening that time" (Tr., Dec. 10, p. 10).

[161]W. Mason (NRC member), "The Safeguards Problem--A Regulatory Perspective," NRC news release, May 13, 1975, submitted for the record, Transcript, November 18, 1975, p. 270.

fabrication of a simple, transportable, fission explosive is not a technically difficult task... [A] crude, low yield fission explosive, such as some terrorist group might be capable of constructing, could kill tens of thousands of people and cause hundreds of millions of dollars of property damage in an urban area."[162] The NRC however felt the chances of someone making a successful bomb were slim:

> "...[A] theoretical knowledge of nuclear physics and the unclassified literature on how nuclear weapons work are not a sufficient basis for the confident design of a practical nuclear explosive. There are many more theoretical designs that will fail than there are designs which will work. The critical knowledge required for designing and fabricating a reasonably reliable nuclear explosive is not theory; it is the practical experience in design, fabrication and testing of actual nuclear devices -- the experience of having tried and experimentally determined what will and will not work and why. This kind of knowledge is not widespread. The risks in fabricating a crude nuclear explosive device are both numerous and significant. The very nature of the activities in such a project, the kinds and numbers of people required, and the materials involved, all combine to make detection of the enterprise difficult to prevent, if not certain.[163]

Would terrorists go nuclear? Even if a group of amateurs could build a bomb, how likely is it an actual attempt would be made? In the opinion of the NRC: "While many things can be conceived as possible, including the fabrication of crude nuclear explosives, that does not mean we automatically accept

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[162]Willrich, transcript, November 19, 1975, p. 3.

[163]Transcript, November 18, 1975, p. 24.

them as being probable. ...The chances of failure and death are substantial and may not be worthy of any objectives contemplated with nuclear explosives."[164]

The director of the Rand Corporation's study project on terrorism suggested that deliberate dispersal of radioactive materials would not appear to fit the pattern of terrorist actions so far, and emphasized that those "most willing to undertake acts which may cause widespread death and destruction may be least able to do so."[165] Terrorists already have access to other materials--poisons or conventional explosives--which could cause massive casualties, but have not used them so far. Thus, he notes that the more extreme nuclear actions imperiling thousands of lives may be less likely, though he does conclude "low-level" incidents (nuclear hoaxes, seizure of hostages, minor sabotage) will increase in the next few years.[166] Finally he suggests serious nuclear incidents will also increase at a gradual rate as the industry grows, though "more effective safeguards... may be developed that will push that point indefinitely into the future."[167]

On the other hand, Dr. Theodore Taylor, the designer of some of our first atom bombs and one of the first to speak out on

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[164]Transcript, November 18, 1975, p. 25.

[165]Jenkins, Transcript, November 19, 1975, p. 67.

[166]Recently a Florida high school student threatened destruction of Orlando with a nuclear bomb and demanded $1 million in ransom. Although the ransom note was accompanied by a diagram of a crude bomb, the attempt was a hoax (The Nuclear Power Alternative, p. 81).

[167]Transcript, November 19, 1975, p. 68.

the possibilities of plutonium theft, suggests the risks of other governments building a bomb from reactor-produced plutonium may be even more serious than terrorism concerns. India recently exploded a nuclear device that used plutonium recovered from a reactor supplied to India by Canada, and Taylor believes there are perhaps 30 to 35 countries today with the desire and the means to produce nuclear weapons if enough bomb-grade material could be obtained.[168]

Plutonium theft by organized crime a strong possibility. Two recent studies completed for the NRC, focusing on organized crime, present a less optimistic view of potential plutonium thefts.

> A veritable array of criminals and hoodlums in this country is waiting and willing to undertake any activity, including murder, if the profit justifies it. Their ruthlessness and sophisticated techniques and methods have been convincingly demonstrated in thousands of skillfully executed crimes. They operate businesses and control large segments of the labor force, thus seriously affecting many aspects of commerce in this country. They have corrupted and compromised men in all walks of life. They have links with many foreign countries. Their greed knows no bounds. The situation is even more dangerous because even the leaders of organized crime do not have absolute control over all the tens of thousands of criminals and killers they have trained. This frightening situation is something which anyone attempting to devise a system to protect nuclear installations and special nuclear material must take into account.[169]

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[168]Transcript, December 10, 1975, p. 5.

[169]Mitre Corporation, "The Threat to Licensed Nuclear Facilities" as reported in Nucleonics Week, December 4, 1975, p. 5.

In-plant gambling activities at nuclear installations were viewed in the studies as a way for the "mob" to gain control over employees in order to obtain information, access and inside help. One study believes if the price is right, organized crime could penetrate nuclear facilities at any time. As an example the report notes Colonel Quadaffi of Libya offered millions of dollars for strategic quantities of plutonium.[170]

NRC has safeguards requirements to protect bomb-grade material. In response to the perceived hazards of plutonium diversion, the Atomic Energy Commission in 1974 adopted requirements for physical protection of plutonium in storage and in transit and for strict inventory procedures to ensure that all bomb grade materials can be accounted for.[171] These requirements include armed guards, physical barriers, access controls, intrusion alarms, security clearances, and armed escorts armored trucks carrying plutonium with communications between the convoy in-transit and a central security office.[172]

Are existing safeguards adequate? The NRC is confident its requirements are sufficient:

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[170] Ibid.

[171] 10 CFR 70 & 10 CFR 73.

[172] Page, Transcript, November 18, 1975, pgs. 11-18.

> It is believed that current NRC safeguards rules, and the safeguards conditions that can be imposed under these rules, will provide adequate protection for the special nuclear materials activities currently being conducted. To date there is no evidence to indicate any loss by theft, or diversions to any unauthorized use of significant quantities of special nuclear materials.[173]

The Atomic Industrial Forum representative stated: "Our present safeguards provide, through physical protection systems and trained personnel, a substantial capability to deal with likely criminal threats against the present small usage of plutonium in the civil sector."[174]

But the safeguards critics are still skeptical:

> In this country, and we have no reason to believe it's very different in other countries that have plutonium, the level of security is not sufficient to stop the kinds of attacks and thefts that have been successful in stealing very valuable materials in the past."[175]

The NRC says it will continually evaluate and upgrade its regulations as circumstances merit, especially in light of the projected increases in plutonium handling.[176] Looking to the future, the Atomic Industrial Forum confidently notes:

> Today's technology and equipment can be used to provide improved and adequate safeguards, at

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[173] Ibid., Transcript, p. 18. However, approximately 150 kilograms of plutonium may still be unaccounted for at fuel facilities. There is no evidence to suggest whether it was stolen or not. It could simply be the result of unavoidable handling losses. (Sacramento Union, April 26, 1976).

[174] Transcript, November 18, 1975, p. 102.

[175] Taylor, Transcript, December 10, 1975, p. 6.

[176] Transcript, November 18, 1975, p. 18.

> acceptable costs for protecting much larger inventories of nuclear materials which are expected in the mid 1980's and later ... For the future there is also a number of promising technical options which can either further improve plutonium safeguards, or can reduce the cost of safeguards or both.[177]

Some critics believe adequate safeguards are at least theoretically possible: "Safeguards against nuclear theft cannot, of course, reduce the risk to zero. However, I believe safeguards can be developed and implemented that will reduce the risk to a very low level."[178] But another believes the realities of the task may be a stumbling block: "The political and institutional problems involved in implementing highly effective safeguards in this county, let alone worldwide, are immense."[179]

Safeguard Measures Could Threaten Civil Liberties. The civil liberties question is a concern of recent vintage. Critics allege "the proposed answer to the threat of nuclear terrorism is safeguards, and the nature of the proposed safeguards is a drastic increase in police powers and a concomitant decrease in civil liberties and personal privacy."[180] Specifically they enumerate concerns such as: security clearances for nuclear industry employees, considering them at best infringements upon the privacy of the employee, his family and friends, and "at

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[177]Transcript, November 18, 1975, p. 102.

[178]Willrich, Transcript, November 19, 1975, p. 4.

[179]Taylor, Transcript, December 10, 1975, p. 7.

[180]Tamplin, Transcript, November 19, 1975, p. 54.

worst, instruments of suppression and reprisal"[181]; intelligence gathering to determine potential terrorists and terrorist groups, asserting that such action has a "stifling effect on dissent and debate which are essential in a free society,"[182] and a federal security force which would inevitably be created to direct and control safeguard activities. They suggest existing agencies (the CIA and the FBI) are already abusing their powers, and that an additional agency with even stronger powers would threaten a free society.[183]

Other critics suggest the most serious concern is actually the measures employed to recover plutonium if it is successfully stolen: "The threat is not so much the special police forces and employee screening procedures that might be set up to protect nuclear materials from theft, but rather the extraordinary abridgment of civil liberties that the authorities would probably deem justified to recover stolen nuclear materials before these could be used to make and explode a bomb."[184] Critics particularly fear proposals to repeal legislation barring illegal searches and to institute martial law in cases of nuclear blackmail, as were suggested in the AEC Environmental Impact statement on plutonium recycling.[185]

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[181]Tamplin, Transcript, November 19, 1975, p. 55.

[182]Ibid.

[183]Ibid.

[184]Holdren, Transcript, November 18, 1975, p. 79.

[185]The Nuclear Power Alternative, p. 87.

One critic concludes, "...I have become convinced that a large nuclear industry is not compatible with a free society--a paranoid society, yes, but not a free society."[186]

The NRC considers the civil liberties problem sufficiently serious to at least devote some attention to it in its ongoing Security Agency Study.[187]

Proponents again charge the critics with exaggeration, claiming that any monitoring of citizens that might be necessary would not be excessive. Proponents see this minimum loss of privacy as a small price to pay for a continued supply of cheap electricity.[188]

7. LIMITATIONS ON UTILITY LIABILITY IN THE EVENT OF AN ACCIDENT.

In the event of a reactor accident, federal law (the Price-Anderson Act) limits the liability for damages to approximately $560 million, even though an official study said damages could reach as much as $14 billion. Critics claim the industry's support for limited liability is evidence of the industry's own uncertainty about reactor safety. Proponents argue that without limits on liability, the potential losses would deter investors. Critics reply that such investor decisions are all a part of the market operating to halt hazardous activities and the market should be allowed to operate. Proponents claim the limits make other benefits of Price-Anderson possible--rapid recovery, no-fault payment of claims, and an immediate

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[186] Tamplin, Transcript, November 19, 1975, p. 55.

[187] Transcript, November 18, 1975, p. 22.

[188] The Nuclear Power Alternative, p. 87.

fund of liquid assets--but critics doubt the benefits in reality are much different than those provided by state law otherwise applicable. The major benefit of Price-Anderson appears to be in providing a level of indemnification not available in the private insurance market. Critics propose ways in which this indemnification can be provided without the liability limit. The industry is divided on whether the limit is still essential.

In the remote chance that there is a catastrophic accident at a nuclear power plant, federal law now limits the recovery for damages to approximately $560 million even though the Reactor Safety Study has said that in the most severe accident the damages could reach $14 billion. Any further recovery would require a special congressional appropriation. This limit on liability is established by the Price-Anderson Act, which also sets up a program to provide the $560 million coverage through private insurance companies (now providing $125 million in insurance) and government indemnity for the difference ($435 million) to be paid out of general tax revenues in the event of an accident.[189]

Critics think liability limits weaken industry's case. Critics claim that the continued insistence of the utilities that their liability be limited and their insurance be subsidized by the federal government is convincing evidence of the industry's own uncertainty about reactor safety. In a

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[189] A recent amendment of the Price-Anderson Act (P.L. 94-197) creates a system of retrospective premiums of $2-5 million per reactor payable by the utility in the event of an accident. This system will phase out government indemnity gradually and will eventually provide funds in excess of $560 million as the number of reactors grows. (see also Fain, transcript, Nov. 20, p. 68.)

comment attributed to law professor Harold Green, the point was driven home: "It is remarkable that the atomic energy establishment has been so successful in procuring public acceptance of nuclear power in view of the extraordinary risks of the technology which are so thoroughly and incontrovertibly documented in the existence of the Price-Anderson Act."[190] An industry witness summarized a competing rationale for the liability limitation in saying:

> Without a limitation of liability, there would be a risk that all of the assets of the utility might be consumed by an accident and in satisfaction of claims in the event of an extraordinary accident. Thus the possibility of loss of security for the investments might well deter those who would otherwise provide investment capital needed to build these facilities. At the very least, it could be expected that the cost, either by way of return on investment or interest on bonded indebtedness, would be greater without the limitation on liability than is the case today.[191]

The critics see nothing wrong with putting the full cost burden of the risk on the utilities. In A Time to Choose, the final report of the Ford Foundation's Energy Policy Project, this same view was noted:

> In most business activities, the potential liability, or the costs of insurance to protect against liability, are recognized as elements of cost by an enterprise considering whether to engage in a hazardous undertaking. If these costs are excessive, the market system automatically halts the hazardous activity. With an enterprise held strictly liable, the market system would be society's first line of defense

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[190]Transcript, November 20, 1975, p. 57.

[191] Ibid p. 69.

> against catastrophic accidents. In the case of the nuclear industry, this safeguard and its powerful monetary incentive for the industry has been replaced by a reliance on the effectiveness of AEC, now NRC, regulation...
>
> It is our view that the nuclear power industry is now sufficiently mature for a revision of the Price-Anderson Act, so that the market place will reflect the potential social costs of nuclear power. If nuclear power is indeed as safe as the AEC and the industry claim, the risks are small enough to be borne by the enterprises involved. If the utilities are unwilling to build new plants on certain sites, or to buy reactors of certain designs, without the shield of Price-Anderson, then those locations and those plants are too risky to be built.[192]

Some critics also allege that by relieving the industry of the liability for serious accidents, Price-Anderson may reduce the vigilance in construction and operation necessary for reactor safety. They say that limited liability removes the deterrent against negligent activity. In support they note the words of William Kriegsman, member of the NRC: "Do away with it (the Price-Anderson Act) and you'd probably see nuclear valves coming off the assembly line in a lot better shape."[193]

Proponents claim limits make other benefits possible. Proponents argue that, on the contrary, the Price-Anderson Act has a number of provisions in additon to the liability limitation which give a degree of public protection otherwise unavailable. These features, summarized in the testimony of a

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[192] S. David Freeman, et. al., A Time to Choose: America's Energy Future, The Final Report of the Energy Policy Project of the Ford Foundation (Ballinger: Cambridge, 1974), pgs. 221-223.

[193] Transcript, November 20, 1975, p. 58.

witness from the Atomic Industrial Forum, are:

(1) Availability of a very large fund of liquid assets for immediate payment in satisfaction of claims.

(2) No-fault liability, imposed through the application of a waiver of defenses, which removes the substantial legal obstacles to recovery under state law.

(3) "Omnibus" coverage which makes the provisions of the Act applicable regardless of who is responsible for the incident.

(4) Emergency payment provisions which permit immediate payment to claimants without awaiting receipt of all claims or even final resolution of individual claims.

(5) Administrative procedures for the consolidation of all claims in one jurisdiction to ensure fair treatment to all claimants together with requirements for the establishment of a plan of distribution including a reserve for latent injuries where appropriate.[194]

Without Price-Anderson, the industry explains, recovery of damages would be slow and difficult in case of a reactor accident. Especially difficult would be proving the causal connection between the accident and an injury, especially in the case of cancers which may not appear for several years.

Critics doubt benefits. The critics feel that some of these supposed benefits of Price-Anderson are themselves illusory. While emergency claims can be paid, only 15% of the total amount can in fact be paid out immediately.[195] Final disposition of claims may not actually be handled promptly since the court must wait for all claims to be filed and then determine how the total amount available is to be apportioned.[196] Since claims

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[194]Transcript, November 20, 1975, p. 68.

[195]Ibid., p. 96.

[196]Ibid.

may not be paid in full, businessmen in the local area may be forced into bankruptcy.[197] Furthermore, defense costs are also to be paid out of the $560 million kitty, reducing the total amount available; defense costs could be as high as $60 million given the experience in analogous situations.[198]

The major alleged benefit of Price-Anderson is that it provides for payment without regard to fault, and waives a utility's ordinary defenses. In a detailed study of the pre-emption issue commissioned by the Atomic Industrial Forum, the following comment is made on the Price-Anderson Act:

> The Act did not create any independent right of compensation for the public. The availability to the public of the proceeds of the insurance and indemnity is conditioned upon the establishment of legal liability (of some person) under existing tort law.[199]

A close reading of the Act reveals a number of important qualifications on the no-fault and waiver-of-defense provisions.

1. The provisions and the $435 million in government indemnity are not involved unless the Nuclear Regulatory Commission declares an accident on "extraordinary nuclear occurrence.[200] Then certain

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[197]Transcript, December 10, 1975, p. 53.

[198]Ibid., p. 51.

[199]Murphy and LaPierre, "Nuclear 'Moratorium' Legislation in the State and the Supremacy Clause: A Case of Express Pre-emption," for Atomic Industrial Forum, 1975, p. 25.

[200]42 USC 2014(j) (1970). An "extraordinary nuclear occurrence" is defined as an incident which has or will probably result in substantial damage to persons or property offsite. The Commission's declaration is unappealable to the courts.

liability issues and utility defenses are waived only when the Commission requires it and only to the extent the waivers are incorporated in prior agreements between the utility and the Commission.[201]

2. The specifics of the waiver are controlled by the prior agreements and are invalid if certain conditions are not met (for example, if an injured party failed to mitigate his exposure--he was notified by radio to stay indoors but went outside anyway) or on the portion of claims in excess of $560 million.[202]

3. If the Commission determines that no extraordinary nuclear occurrence has taken place, legal relief is totally subject to the federal courts' interpretation of relevant state law. Therefore, for the more probable insubstantial accidents, the federal "no-fault", or strict liability, proxy would not apply.

4. The waiver of defenses only covers showings the plaintiff would ordinarily have to make that the utility had a certain duty or standard of care and that there had been a breach of that duty (conditions to establish fault). The waiver would <u>not</u> remove the need to show (a) the accident was the proximate cause of damages or (b) the extent of the damages.

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[201] 42 USC 2210 (n) (1) (1970)

[202] <u>Ibid.</u>

In a jurisdiction such as California which liberally interprets the applicability of legal doctrines of strict liability and ultrahazardous activity, one could argue that the Price-Anderson Act provides no real advantages to a damaged party which he would not otherwise have under state law.[203]

Price-Anderson provides indemnification otherwise not available now. The major salient feature of the Price-Anderson Act, then, seems to be the level of indemnification it provides which would otherwise be unavailable. The Price-Anderson Act has its origin in 1957 when the commercial nuclear power industry was in its infancy. At that time it was recognized there could be a substantial third party liability involved in the "remote chance" of an accident, but consultation with private insurance carriers revealed there was not the capacity available to protect against that risk.[204] Through pooling their resources, the private insurance companies were able to offer protection in the amount of $60 million. Realizing this amount of coverage did not allay the fears of the utilities otherwise interested in using nuclear power, the Congress did two things: (1) It established a program of government indemnity for an arbitrarily set $500 million, and (2) it provided that the liability be limited to the sum of these resources--$560 million.[205]

A 1973 Columbia Law School study, "Issues of Financial Protection in Nuclear Activities", commissioned by the Atomic

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[203]Transcript, November 20, 1975, pgs. 35 and 40.

[204] Ibid p. 67

[205]Ibid.

Industrial Forum, commented on the legislative history of the $560 million limitation: "One rationale advanced for limiting the government's obligation to $500 million was that a claim for that amount would not significantly disturb the government budget. In the end the figure of $500 million was chosen because it was small enough to 'not frighten this country to death' but probably large enough to protect industry."[206]

The industry claims the $560 million limit does not mean that further relief would not be provided in the event of larger accidents. Should it ever be necessary, they say, the Congress would take the appropriate action to increase government assistance. This view is substantiated by the report of the Joint Committee on Atomic Energy, accompanying the 1965 extension of the Act: "The limitation of liability serves primarily as a device for facilitating further Congressional review of such a [large accident] situation, rather than an ultimate bar to further relief of the public."[207] In the most recent extension of the Act, Congress also added intent language to the same effect.[208]

Is limited liability still necessary? To the critics, even if Congress were to provide special nuclear disaster relief, the parties responsible for the accident would still not be held liable, a situation they find unsatisfactory. They prefer a

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[206] Transcript, November 20, 1975, p. 57

[207] Ibid. p. 68

[208] "In the event of a nuclear incident involving damages in excess of that amount of aggregate liability [$560 million], the Congress will thoroughly review the particular incident and will take whatever action is deemed necessary and appropriate to protect the public from the consequences of a disaster of such magnitude." (P.L. 94-197, 89 Stat. 1113).

system where the full cost of an accident would be borne by the utilities using nuclear power. The beneficial provisions of no-fault, consolidation of claims, emergency payments, and waiver of defenses which are now a part of Price-Anderson can be retained while eliminating the limitation on liability, say the critics. In place of the system of government indemnification, the critics propose a combination of private insurance, retrospective premiums, and self-insurance.

(I) Private insurance. Over the years, the amount of insurance available from the pools of private carriers has increased to $125 million,[209] but the companies contend even now they do not have the capital resources to risk much more than that.[210]

(2) Retrospective premiums. In order to make up the difference in the event of claims in excess of $125 million, critics suggest a layer of bonded retrospective premiums on each licensed reactor, payable only in the event of an accident.[211] The bond would insure the funds would be available when needed, so that capital will not have to be tied up unnecessarily.[212] Some critics have suggested the premiums be set at $10 million to $20 million per reactor. For the 58 reactors now licensed, that

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[209]The increases have come apparently at the prodding of the chairman of the Joint Committee on Atomic Energy (Transcript, November 20, 1975, p. 105.

[210]Transcript, November 20, 1975, p. 111.

[211]A system similar to this was established by P.L. 94-197, December 31, 1975. See supra, footnote 189.

[212]Messing, material submitted for the record, transcript November 20, 1975, p. 225.

D. JUDGING THE NUCLEAR DEBATE

To any lay observer, the claims and counterclaims that are made about the safety and wisdom of the nuclear power program in this country are bewildering. Scientists themselves are unable to agree on where virtue lies. In a display of at least some levity, the public has been treated to the battle of the Nobel laureates, a game of escalating numbers. First, two Nobelists, Linus Pauling and Harold Urey, indicated their reservations about the continued development of nuclear power. Then, under the prodding of Hans Bethe, another Nobel prize-winner, 32 scientists signed a statement indicating that in their view nuclear power was safe and a necessary energy option for this country--eleven were Nobel laureates. The Union of Concerned Scientists next circulated a petition indicating the need for caution and the need for more safety testing prior to rapid expansion of the use of nuclear power and obtained the supporting signatures of 2300 scientists, a large proportion of whom were specialists in nuclear energy or nuclear physics. Then the New Mexico Citizens for Clean Air and Water, an environmental group of some 2000 members, a few hundred of whom work at the government's nuclear energy lab at Los Alamos, issued a proclamation that unless "potentially serious problems" were clearly on their way to solution by March ,1977 the group would oppose further construction of nuclear power facilities "as an imminent hazard." Finally the American Nuclear Society gathered 32,000 signatures on a declaration that both coal and uranium

are needed as power sources and that "there are no technical problems incapable of being effectively solved" in using these fuels.

The reason for the dispute among highly qualified and knowledgeable men is that the issues are not solely resolvable through application of scientific expertise. The debate is more the result of differing views on human abilities, human fallibility, and human behavior than anything else. To have confidence in the safety of a reactor, we must have confidence in the degree of perfection man can attain in building and operating complex devices. To have confidence in the perpetual isolation of nuclear wastes, we must have confidence in the longevity of our social institutions and the rationality of future generations. To have confidence in the security of the bomb-grade fuels which are present in the cycle which results in electricity, we must have confidence in the abilities of society's deterrents to prevent actions by fanatics or organized crime. If one is pessimistic about these requirements, one does not agree with the course currently being followed to expedite the development of nuclear power. If optimistic, one is dismayed by what appear to be irrational roadblocks constantly being thrown in the way.

Alvin Weinberg, former director of the AEC's (now ERDA's) Oak Ridge National Laboratory, has said: "When nuclear energy was small and experimental and unimportant, the intricate moral and institutional demands of a full commitment to it could be ignored or not taken seriously. Now that nuclear energy is on

the verge of becoming our dominant form of energy, such questions as the adequacy of human institutions to deal with this marvelous new kind of fire must be asked and answered soberly and responsibly."[215] The commitment to nuclear energy Dr. Weinberg described as a Faustian bargain: "On the one hand we offer--in the catalytic nuclear burner [the breeder reactor]--an inexhaustible source of energy...But the price we demand of society for this magical energy source is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to." Dr. Weinberg indicated the issues should be "adjudicated by a legal or political process rather than by scientific exchange", because the questions are beyond the resources of science to resolve. He concluded that the benefits of developing nuclear power were greater than any risks involved. But others in using his same calculus came to the opposite conclusion.

It is not as if there is no role for technical information in this debate. But what is confounding is that in the absence of hard evidence, the facts on which to base our normative judgements are themselves disputed. Much of the information required is a prediction of future events on the basis of limited experience. This is in essence the nature of the dispute over the Reactor Safety Study and the problems of waste disposal. The crucial tests have not been done and on the whole many of the critics would be more at ease if they were presented convincing data from actual experiments.

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[215] A.M. Weinberg, op. cit.

Overall then, the positions on both sides are matters of speculation. To decide between conflicting viewpoints, one is thrown back on his faith in one set of speculations over another.[216] In this situation, it is clear that the industry and the old AEC suffered from public mistrust by being overly optimistic in the face of increasing evidence that there were problems. To some extent this reaction is attributable to the extreme degree of scrutiny to which the nuclear industry is subjected. Because of this scrutiny, more problems in the nuclear industry come into public view than in practically any other heavy industry. To balance what some in the industry believe is the excessive attention given them, public pronouncements expressing great confidence that problems will quickly be remedied or downplaying the significance of any particular incident, are issued. In the past practically no problems were ever admitted to by the AEC or the industry. The actions of the industry and their federal regulators appear overly defensive to some and lead to mistrust and suspicion. Now this situation appears to be changing slowly.

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[216] Nobel laureate, Dr. Hans Bethe, nuclear power proponent, was asked during the hearings if the ECCS would work when needed. He answered: "I do not know, and the people who know much more about it, like Dr. Finlayson who was a member of the [American Physical Society] panel, do not know either. On the other hand Dr. Finlayson...went on record to say that he has the feeling that it will work. ...[the] best you can do is to rely on the feeling of people who have studied it very carefully..."

Apparently the poor performance and problems in nuclear plants were as much of a surprise to the utilities as anyone else. As a result there has been open disputes between utilities and nuclear vendors, each blaming the other for the problems that have arisen (e.g. SMUD and Westinghouse). At least one utility, American Electric Power Company, has been openly skeptical of the continued use of nuclear power. Others in the industry have been doubtful of the prospects of economical fuel reprocessing and the skyrocketing price of uranium has caught one major vendor completely off guard. Other business groups of a traditional conservative grain are even publicly criticizing such main line projects of the nuclear power program as the liquid metal-cooled fast breeder reactor. ERDA itself has laid bare the problems in uranium enrichment capacity, fuel reprocessing, plutonium recycling, and waste disposal which it has not yet been able to solve. But the critics' case is not conceded. There are still a good number of serious allegations that have been leveled by various critics which the industry, ERDA, and the NRC do not find well-founded.

Generally, the position of the nuclear industry, ERDA and the NRC is that the use of nuclear power is fraught with hazards but that the problems are being dealt with adequately, changes are made when necessary, and the record to date is excellent. In response, the critics charge the Federal Government with being too lax in its regulation. One group said "an electrical appliance, such as a toaster or a hair dryer, has more stringent safety checks than the electrical instruments that control a

nuclear plant. This is a clear demonstration of the inadequate attention given by the NRC towards protecting the public safety."[217] Another critic obtained an admission from an AEC official that only 2% of a plant design was ever reviewed for safety.[218]

But virtue is not entirely on the side of the critics either. They often have been guilty of continuing to use outdated information and making exaggerated claims. Some base their criticism more on a general anti-big-business attitude than on specific safety questions.[219] The most common problem is over-stating the ease with which conservation and alternative sources of energy could take up the slack left by an abandonment of nuclear power. But in balance it is likely that the industry is similarly over-enthusiastic about the low cost of electricity generated from nuclear heat compared to alternative fuels. Nevertheless there does appear to be a segment in the spectrum of critics which is careful and responsible and willing to recant in light of new evidence.

The result of the tension between the industry, the critics, and the responsible government agencies has been a pattern of events reminiscent of the debate over the Vietnam War.

--Official optimism despite continued revelations of negative evidence.

--Exposure of embarrassing information purposely withheld from the public (the '64-'65 WASH-740 update obtained through a suit under the Freedom of Information Act).

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[217]Testimony of Dale Bridenbaugh, Richard Hubbard and Gregory C. Minor (three former G.E. officials) to the Joint Committee on Atomic Energy, February 17, 1976.

[218]Cherry, transcript, November 20, pg. 47.

[219]This was the essence of the testimony from the National Intervenors, transcript, October 29, pgs. 62-76.

--Defections of middle level people from one side to the other. Carl Hocevar, a nuclear engineer working on the emergency core cooling computer codes at the AEC's Idaho Reactor Testing Station, resigned to join the Union of Concerned Scientists, the group most vocal in their criticism of the Computer codes. Ian Forbes, one of the first members of the UCS, resigned when he felt his colleagues were overly critical of reactor safety after the AEC modified its ECCS criteria. Then three GE engineers from middle level management in the nuclear division bailed out and criticized the safety of BWR's, and have been campaigning for the passage of the initiative. In frustration over what he regarded as the failure of the Nuclear Regulatory Commission to be concerned first and foremost with safety, Robert Pollard, the NRC manager in charge of the safety review for the Indian Point 3 reactor, resigned and took his case to the media.

--"Excommunication" of "heretics". Persons who choose not to resign but to voice criticisms from within have been made so uncomfortable they felt compelled to leave. This seems to be what happened to Arthur Tamplin and John Gofman (who challenged radiation release standards as being too high) and Donald Geesamen (who believed plutonium was more toxic than officially thought).

--Anonymous leaks of withheld agency information to critics engaged in legal actions against the industry and the federal agencies.

These tensions have increased remarkably in the last two years, and it looks as though the tensions will continue to build. No program can be subjected to this level of criticism, showing signs of internal discord, and continue unchanged. Some sort of reassessment will undoubtedly occur, probably within the next five years.

CHAPTER FOUR

MECHANISMS FOR REASSESSMENT

If it is concluded that a reassessment is required, the problem then becomes one of the nature, extent, and operation of such a reassessment, as well as the competence and public credibility of the entity undertaking the project.

The public trust element is most important, given the past performance of federal regulators, particularly the U. S. Atomic Energy Commission.[220] In the opinion of one witness, the former AEC consistently "substituted smooth public relations for meaningful review."[221] Dr. Edward Teller characterized the former head of the AEC's reactor development division as a "monomaniac" uninterested in certain reactor safety research even though it was his assigned duty.[222]

During the AEC years, it was often argued that the problem stemmed from a conflict between promotional and regulatory functions assigned to a single agency. Congress severed the two functions in the Energy Reorganization Act of 1975, giving the sole function of safety regulation to the Nuclear Regulatory Commission, and a multi-faceted energy development mission, which included nuclear power, to the Energy Research and Development

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[220] An internal AEC memo of May 1974 said the credibility record of the Commission was poor because it simply had not been enforcing its own regulations (transcript, October 21, 1975, p. 79).

[221] Ebbin, Transcript, October 29, 1975, p. 55.

[222] Transcript, October 21, 1975, p. 11.

Administration. Some commentators believe the NRC in its first year of operation has been tougher than the old AEC in regulating nuclear safety.[223] But in the reorganization, ERDA inherited responsibility for nuclear safety research and one witness contended nothing had changed from the days of the AEC.[224]

Nuclear reactor manufacturers and operating utilities expressed the view that, generally, existing agencies are being overly cautious, for example, in requiring all reactors of a generic type to shut down and inspect for cracks in piping which were discovered in that type of reactor elsewhere. The industry therefore believes through a continuation of safety research, vigilance by the NRC, and careful scrutiny, no particular additional review is necessary. ERDA and the industry also point to the review now underway in the National Academy of Sciences as a sufficient external critique. Critics hardly agree.

What makes an independent reassessment particularly difficult in this situation is the absence of any middle ground. On both sides there is an attitude of "if you're not for us, you're against us". So far the study done by the American Physical Society has come the closest to the middle ground, as both a nuclear power proponent and critic were able to sit in front of a Congressional committee, wave the study and add "See, this proves what I've been saying all along."[225]

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[223] Nucleonics Week, April 8, 1976, p. 6.

[224] Ebbin, transcript, October 29, 1975, p. 55.

[225] Lewis, transcript, October 29, 1975, p. 35.

The other key issue brought to a head by the Initiative as a reassessment mechanism is the question of what to do about plans to build more reactors while the studies are being undertaken.

Spectrum of options for reassessments. There seem to be three major options for conducting a comprehensive, independent reassessment.

> (1) Shut down existing plants and build no more until the studies have been completed. In the opinion of one witness, a moratorium on further development would stifle safety research since if other types of plants were being built there would be no particular incentive to do the tests which would resolve serious safety problems.[226]
>
> (2) Continue operating existing plants and finish those under construction, but begin no more until the studies are completed. This option would place less of a burden on utilities to find replacement generating sources immediately.
>
> (3) Continue to build new plants to gain more operating experience and conduct studies simultaneously; put more effort into data collection and retrofitting of operating plants with the latest equipment. To the critics, continuing to build more plants simply means that if the results of the reassessment were negative, it would be too late to do anything about it. The reactors would already be in place and it would be politically impossible to shut them down. Some critics don't seem to mind the program eventually going ahead so long as the tests are done first. Nuclear power proponents believe that nothing so serious as to jeopardize further construction of nuclear plants will result from the reassessment, so that continuing the construction schedule makes good sense.

The important question then is how the Initiative measures up as a mechanism for reassessment.

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[226]Bethe, transcript, October 22, 1975, p. 9.

or less,[231] others firmly believing California's growth in electrical energy demand can be held to 1.2% annually.[232] The measures suggested to produce such savings included: increased efficiency of appliances; weatherstripping, insulation, and double pane windows; reducing lighting in buildings; and cutting the number of windows on east-west exposures.[233] These measures were chosen because they involved no lifestyle changes. These measures, even though they involve some initial added expense, are supposed to return net dollar savings to consumers over time.[234] Some contended that "producing" energy through investments in conservation--freeing up energy to be used elsewhere--is the cheapest source of supply available, equivalent to oil at $5 per barrel.[235]

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[231]"...fuel conservation...[is] the best single strategy for simultaneously stretching out our limited fossil fuel resources, holding down energy costs, minimizing dependence on foreign energy sources, and protecting the environment...it is entirely feasible for the U. S. to pursue something approaching zero energy growth for several decades without economic hardship..." Williams, transcript, December 2, 1975, p. 59.

[232]Goldstein & Rosenfeld, transcript, December 3, 1975, p. 193.

[233]Williams, transcript, December 2, 1975, pgs. 60-62; Schipper, transcript, December 9, 1975, pgs. 26-28; Hammond, transcript, December 9, 1975, p. 117.

[234]Williams, transcript, December 2, 1975, p. 65.

[235]Transcript, December 9, 1975, p. 59.

If a growth rate of 1% per year could be achieved, all new nuclear plants could be postponed or cancelled along with many of the new non-nuclear plants. Other witnesses were less optimistic. Dr. Penner, from the University of California at San Diego, agreed large savings are physically possible, but a number of non-technical difficulties prevented total success. He suggested that at best only half the maximum savings would be realized and it may be 8-10 years before any savings are noticeable.[236] California had one experience where significant savings were realized in the short term, though. During the 1973-74 oil embargo the City of Los Angeles instituted a mandatory conservation program which reduced electricity consumption 17% compared to the previous year.[237] However, the mandatory program was rescinded and the savings are disappearing as the novelty and "patriotism" of the situation wear off.[238]

While few industry or utility witnesses offered an estimate of potential conservation savings, W. Kendall Davis, Vice-President of Bechtel Power Corporation felt that conservation could only cut the growth rate down one percentage point.[239] This was also the view of researchers from the Rand Corporation drawing on a prior study done for the Committee.[240]

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[236]Transcript, December 2, 1975, p. 95. The same view was expressed by ERDA (transcript, 15, 1975, p. 44).

[237]Tamaki, ranscript, December 3, 1975, p. 103.

[238]Ibid; Laffoon, transcript, October 14, 1975, p. 94.

[239]Transcript, October 15, 1975, pgs. 76-77.

[240]Transcript, October 14, 1975, p. 112.

Government action need if conservation to succeed. All witnesses agreed that voluntarism was insufficient and any major conservation efforts required aggressive government action. In California certain conservation measures have already been adopted and the new Energy Commission is mandated to recommend additional measures to the Legislature and Governor for implementation.[241] But the Federal Government has not adopted any mandatory measures, choosing instead to work with industry asking for voluntary cutbacks and to appeal to the public.[242] Federal studies on conservation are continuing and ERDA is devoting $71 million to conservation research this year.[243]

Fossil fuels as replacements for nuclear energy. Presently, oil, natural gas and coal provide the primary energy for 61% of the generating capacity serving California. Utilities, rather than maintain this proportion, plan to reduce the percentage by building nuclear plants. If nuclear plants cannot be built, the obvious alternative would be to continue building fossil fuel-fired plants as has been done in the past. There seem to be three objections to this approach which may make a reassessment difficult:

(1) Electricity generated in oil or coal burning plants is more expensive than that from nuclear plants;

(2) Burning oil and coal means more environmental degradation; and

(3) A variety of governmental regulations constrict the number of fossil fuel burning plants which can be built.

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[241]Chapters 4 and 5, Division 15, Public Resources Code; Part 3, Division 13, Health and Safety Code (commencing with Section 19870).

[242]Transcript, October 15, 1975, pgs. 26-27.

[243]Transcript, October 15, 1975, p. 47.

The cost differences between fossil fuel and nuclear plants uncertain. If demand were reduced, utilities would cut back on their most expensive generating sources first, in general herefore, conservation or revised estimates of future demand would not reduce the need for nuclear plants if they were the cheapest generation source. Oil-fired plants are generally recognized to be the most expensive base-load source of electricity. However, the cost difference between coal fired plants and nuclear plants is not so clear. As this report has previously discussed, the costs of producing electricity at a new nuclear plant have been increasing very rapidly. Coal-fired power plants to provide power to the State now look fairly cheap and, in some cases, appear to be almost on a par with nuclear plants.[244] This situation may change rapidly, too, as mining costs escalate and expensive pollution abatement equipment is added. Estimates of future costs of either nuclear plants or fossil fuel plants have been very uncertain recently. One can find legitimate studies which show on the one hand power costs twice as high for nuclear as for coal, and on the other, nuclear two-thirds the cost of coal.[245]

Fossil fuels and environmental degradation. Burning oil or coal to make electricity creates environmental costs in

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[244]Transcript, October 14, pgs . 34,36,37

[245]"Data on Nuclear Power Costs, Benefits Conflict," Larry Pryor, Los Angeles Times, April 4, 1976.

extraction (oil spills, strip mining) and use (sulfur oxide, nitrogen oxide, and particulate air pollutants). However, nuclear plants have analogous impacts (radon emissions in mining, radioactive emissions from the power plant and the fuel reprocessing plants) along with the potential for catastrophic impacts (reactor accidents). The question is whether the pollution penalties of using coal or oil are worse than those for using nuclear power, not whether we should use "dirty" fossil fuels rather than "pollution-free" nuclear power. Both pollute. It's a matter of degree and relative impact.

Institutional constraints on fossil fuel development. Fossil fuel fired plants are becoming harder to use because of restrictions placed on the amount of pollutants they can limit and on the disruptions which can be caused in order to extract the fuels. In addition, coal development in the West may be constrained by water supplies and manpower and equipment availability. Some witnesses believed expansion of coal mining in the West was seriously constrained,[246] but one FEA witness indicated the rate of coal production was demand-limited rather than supply-limited.[247] To the extent these constraints are real, substituting fossil fuel use for nuclear energy will be difficult. But the possibility

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[246]Thorne, Transcript, December 3, 1975, p. 8.

[247]Rosenberg, Transcript, December 3, 1975, p. 18.

also exists that utilities will be prevented from building as many reactors as they had intended, due to serious constraints in uranium supply, enrichment capacity, fuel reprocessing, and the absence of key regulatory decisions.[248] Other forms of generation may have to be substituted for nuclear power, whether or not a reassessment is conducted.

Because of the possible cost, pollution, and institutional constraints on both the use of nuclear power and fossil fuels, solar and geothermal energy are often advocated as replacements.

Can solar and geothermal energy replace nuclear? The expanded use of solar and geothermal energy is hampered by the absence of commercially viable technologies and large-scale equipment manufacturing industries. The utilities in California plan to install 3258 MW of geothermal power plants by 1995. Nuclear power critics believe the use of geothermal and solar energy can be expanded well above this figure. Proponents of nuclear power argue that even with accelerated research programs, geothermal and solar energy will not make large enough contributions in the next 20 years to displace nuclear power.[249] According to these witnesses, geothermal energy may contribute as much as 5000 MW by 1995,[250] but this would represent only 6% of

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[248] One utility planner, frustrated over the constraints on nuclear power said: "No enrichment, no plutonium recycle, no fuel cycle licensing, no limited work authorizations, no standardization. You can't get anything done" (Nucleonics Week, July 10, 1975, pg 3).

[249] Transcript, October 15, 1975, p. 73.

[250] Transcript, October 15, 1975, p. 78.

needed capacity and would require the utilities to double their projected rate of geothermal development. Solar energy might replace another 5-7% of planned capacity as an upper limit by the year 2000,[251] but many are skeptical of this figure.

Critics contend one reason for this inability to use geothermal and solar energy quickly is a pronuclear bias within the federal energy R & D establishment.[252] Another reason reason cited is the disinterest of large companies with investments in other energy sources to protect.[253] ERDA replied that it has a fast-growing and substantial budget for non-nuclear R & D and that it simply takes time to solve the problems on the road to commercial application of new energy sources.[254] Critics believe a crash program, if the government were committed to it, would bring solar and geothermal energy into widespread use very rapidly.

Utilities take a conservative stance on these four uncertanties. Inferring from the testimony presented by all the utilities in the State, they appear to believe that demand will

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[251]Penner, Transcript, December 2, 1975, p. 15.

[252]ERDA's estimated 1977 budget allocated $204 million to non-nuclear R & D ($122.9 million to solar and geothermal) and $3,940.9 million to nuclear R & D(Nucleonics Week, January 23, 1976, pg. 1). Ralph Nader comments: "The most overriding characteristic of our energy problem is the systematic avoidance of solutions" (Transcript, December 2, 1975, p. 14).

[253]Transcript, December 2, 1975, p. 15.

[254]Transcript, October 15, 1975, pgs. 38-39.

continue to grow but at somewhat reduced rates, energy conservation will be only marginally effective, the solar and geothermal potential in the next 20 years is small, and nuclear power will be cheaper than its fossil fuel alternatives. To an extent, this represents a traditional conservatism which characterizes the utilities. It is grounded in a number of rationales:

First, it is safer to overestimate demand than to underestimate it;

Second, utilities seem to believe the opposition to fossil-fuel burning plants, especially coal plants, would be much more intense than for nuclear. Further, the "rules of the game" for constructing large coal and oil plants are in flux right now and they appear to be afraid this will translate into a series of delays and disappointments. The uncertainties which concern seem to them are: (a) the debate over strip-mining protection regulations in the West; (b) the proposed new state air pollution rules which may preclude any new fuel-burning plants in the State larger than 35 MW; and (c) the political resistance to more out-of-state coal plants;

Third, utilities have experience with building and operating nuclear plants in this State and this experience gives them confidence in nuclear as a major power source. They do not have similar confidence in untested geothermal and solar technologies.

Given these perspectives, it is not surprising the utilities see nuclear power as giving them needed flexibility and accordingly believe any reassessment may be costly. The critics of course

downplay the costs. The key question one must ask, therefore, is whether a reassessment potentially would produce offsetting benefits, and whether any pause in the construction of nuclear plants will be put to good use.

CHAPTER FIVE

PROPOSITION 15 AS A REASSESSMENT MECHANISM

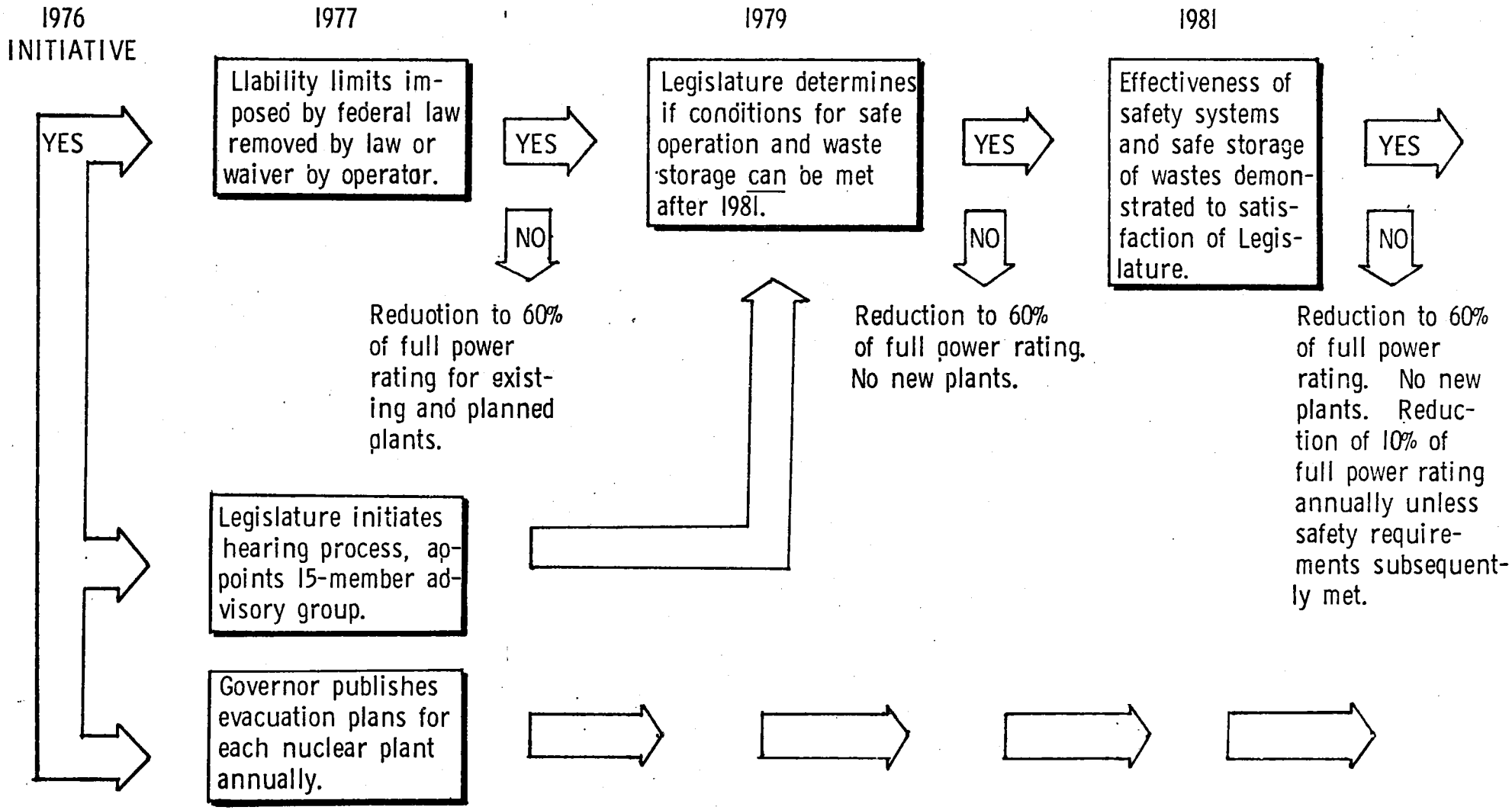
Summary of Provisions.

Proposition 15 is structured so that unless several criteria are met, existing plants are forced to partially curtail their output, no new plants may be built and ultimately existing plants would be phased out. The Initiative does not necessiarily mean any plants will be shut down or that new plants will be prohibited. The criteria which must be met are clustered into three major decision points (See Figure 4), which will occur on 1977, 1979 and 1981. (A copy of the Proposition is included as an appendix to this report.)

Decision 1 deals with the limits on liability for a reactor accident imposed by the Price-Anderson Act. Unless the liability limit is removed, either by federal law or waiver, by June 8, 1977 (one year from the date of passage of the Initiative) and full compensation for any accident is assured, all nuclear plants in operation or under construction would be limited to an output of 60% of maximum (Section 67503(a) and 67504(a)). If the liability limit still has not been removed by June 1981, then the plants will be derated an additional 10% of the original full power level per year (Section 67504(b)). The utilities estimate that they would shut a reactor down completely if it could operate at no more than 20-30% of full power because it would be uneconomic below that point. The Initiative also requires that liability and full compensation be extended to

FIGURE 4

FLOW CHART OF NUCLEAR INITIATIVE



cover personal injury or property damage resulting from attempted theft of nuclear material or accidents in the preparation, transportation, reprocessing, and storage or disposal of fuel and wastes.

Decision 2 is a preliminary assessment of nuclear safety. According to the Initiative, the Legislature is given the ultimate responsibility to determine whether nuclear power is safe. In its deliberations, the Legislature is to be advised by a panel of 15 people, including experts and concerned citizens (Section 67507). The sum of $800,000 is appropriated for the activities of the advisory panel. The Legislature is to focus on (a) whether all reactor safety systems are adequate as demonstrated by comprehensive testing, and (b) whether the radioactive wastes from nuclear plants can be stored or disposed of, with no reasonable chance of escape of the wastes which could adversely affect the people of California (Section 67503(b)). If the Legislature by June 8, 1979, with the advice of the 15-member panel, cannot agree by a two-thirds vote that safety systems and waste disposal systems may be found to be adequate by 1981, then (Section 67506):

1. Plants in operation and under construction are derated to 60% of full power.

2. New nuclear plants are prohibited.

If the Legislature does determine by a two-thirds vote that safety and waste systems may be found to be adequate by 1981, no sanctions are imposed.

Decision 3 is the ultimate decision on whether safety systems are in fact adequate and radioactive waste can be

disposed of with little risk to future generations. If by June 8, 1981, both houses of the Legislature determine by a two-thirds vote that these criteria are met, no restrictions are placed on nuclear power plants. If the Legislature lacks a two-thirds majority, then (Section 67504(b)):

1. Plants in operation and under construction are derated to 60% of full power.
2. New nuclear plants are prohibited.
3. Operating plants are derated an additional 10% of their original full power level each year.

Evacuation Plans. In addition to the deliberations on safety, the Initiative requires the Governor to collect and publish annually the evacuation plans for all nuclear power plants operating in California and provide for the review of such plans by affected agencies and the public. In the Reactor Safety Study the consequences of a serious accident were reduced by the speedy evacuation of the surrounding population.

Evaluation of Proposition 15.

Critics of the Initiative find problems in the procedural requirements, in the substantive provisions, and in the side effects the Initiative may produce.

It is important for the voter to understand that a traditional tactic employed to oppose a piece of legislation is to characterize specific provisions as unrealistic, unworkable, and irrational, emphasizing extreme situations, but avoiding discussion of the broader policy questions it addresses. The standard responses to this rhetorical device on the legislative process are: (1) the evaluation of the source and nature of the criticism as to good faith and credibility; (2) the ability to debate the

extremity and degree of reasonability of the criticism; and (3) amendment to clear up ambiguities which seem to be reasonably present or to produce workable provisions. However, with an initiative such as Proposition 15, there is no opportunity for amendment. Criticism of the details of the Initiative must therefore be evaluated in light of the reasonability of the Legislature in interpreting its provisions, the degree of flexibility in the Initiative, and the probable course of its implementation. The evaluation should consider whether the criticized outcome will be likely to occur, given the prior record of the Legislature, not just whether it is possible.

In some cases critics of the Initiative have clearly overstated the effect of its provisions. For example, one witness claimed the Initiative required the Legislature to find that no acts of God would occur which could disturb stored radioactive wastes.[255] In fact the Initiative asks the Legislature to determine that wastes will be stored safely enough that disruptions such as earthquakes, acts of war, or acts of God will not result in the escape of wastes to the extent the land or residents of California would be adversely affected. This is substantially different criterion than the witness portrayed.

In reviewing the problems with Proposition 15 which witnesses identified, such obvious excesses are not considered. For the remaining criticisms, the discussion will begin with a presentation of the issue a particular provision in the Initiative tries to address, the criticisms and counter arguments which have been voiced, and an evaluation of the probable course of events.

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[255]Transcript, December 2, 1975, p. 55.

A. PROCEDURAL CRITICISMS

1. Two-thirds Vote Requirement.

On the theory that weighty decisions should be undertaken with a degree of conservatism, the drafters of the Initiative required that the legislative findings be made on the basis of an extraordinary majority.[256] The two-thirds vote is now applied in the Legislature to the passage of the Budget Act each year, to any bills which raise taxes on corporations, and to all appropriation measures. Because such matters are dealt with routinely in the Legislature, the backers of the Initiative see no reason the two-thirds vote requirement poses exceptional difficulties. Objections have been raised because the findings of the Legislature are structured in such a way that an affirmative vote is required simply to maintain the status quo. Failure of the two-thirds vote would preclude future construction of nuclear power plants. One reason those opposed to the Initiative foresee an inability of the Legislature to muster a two-thirds vote is the disagreement over nuclear safety within the scientific community itself. The proponents on the other hand feel that if there is enough scientific dissent to convince more than one third of the members of either house, then the risk should not be undertaken.

Critics of the Initiative are concerned that only 14 Senators could block the continued construction of new nuclear plants in the state if the Initiative passed. However, a substantive vote of three members of the Energy Commission, or

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[256]Pesonen, Transcript, December 10, 1975, p. 23. He also noted that in civil cases in court, the awarding of damages requires a three-fourths majority of the jury.

of three members of the Public Utilities Commission, an even smaller number, could have the same effect under existing law.

In actuality, the critics are objecting to the political leverage they believe this two-thirds vote requirement would give to the anti-nuclear factions in the state. The voter must make a value judgment on whether the advantages the extraordinary majority may impart to the anti-nuclear factions is advisable.

2. Five Year Time Limit The Initiative sets a definite time within which the Legislature must make a final determination on reactor safety and waste disposal adequacy--five years. However, there is substantial disagreement whether sufficient information could be generated by that deadline to allow the Legislature to make its judgment. The argument turns on whether tests presently planned by ERDA (1) will meet the requirements of the Initiative and (2) will produce results soon enough. The criteria set by the Initiative for the two decisions by the Legislature--reactor safety system effectiveness and waste disposal safety--may require two different levels of detail and comprehensiveness in the date needed. The decision on reactor safety is to be based on "comprehensive testing in actual operation." Waste disposal techniques, on the other hand, are to be reviewed simply to determine that they can be safely stored even considering the chance of disruptive events. While the Legislature could ask for some sort of laboratory testing of solidified waste, it is not required to do so by the Initiative.

Given the requirements, there is doubt the planned ERDA tests of reactor safety (LOFT and PBF) are adequate. These tests have been characterized by some witnesses as unrepresentative of conditions within a real reactor[257] and certainly are not designed to test comprehensively all emergency systems and safety features. The Initiative, however, requires the demonstration of the adequacy of all safety systems by testing on substantially similar physical systems.[258] One witness, formerly from ERDA's Idaho reactor testing station, commented that in his opinion, the Legislature could not make its determination on the basis of information available today.[259] But Edward Teller commented that if the Legislature were not now satisfied with the safety of reactors after their excellent record, he was uncertain whether the Legislature could be convinced even after another five years of study.[260] Scientists coming before the committee were split on the question of whether information from the ERDA tests, regardless of whether the tests are adequate, would be produced in time: two believed data would be ready in five years, three thought a minimum of 8 to 10 years were necessary. If additional tests are necessary, it begins to look less likely that five years is enough time.

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[257]APS Report, mentioned supra at p. 40.

[258]Section 67503(b) of Proposition 15.

[259]Hocevar, Transcript, October 21, 1975, pgs. 60-61.

[260]Transcript, October 21, 1975, p. 18.

For radioactive waste disposal methods, ERDA's test plans seem less advanced than for reactor emergency systems. They plan pilot facilities for salt disposal in the early 1980's and similar facilities for pilot operation in other geologic formations (domed salt, granite, shale, etc.) in the mid to late 1980's.[261] Earlier pilot projects in deep salt formations have encountered unexpected difficulties. Since the Initiative does not require actual testing of disposal facilities, feasibility studies and laboratory tests may suffice. The Legislature must satisfy itself that the wastes can be stored or disposed of with no reasonable chance that through whatever means wastes would escape and threaten the lives or the property of the public.[262] The evidence necessary for such a decision is left unspecified. ERDA now has available feasibility studies and laboratory tests on waste disposal. If the Legislature does not find this information persuasive, there would be some time to conduct more studies. But if the Legislature believes extensive additional testing is required, five years again may be too little.

The Initiative proponents seem to believe the Initiative will stimulate a more complete and rapid testing program on the part of the Federal Government in order to prevent a moratorium in California and thus argue that the time limit is reasonable. They remain relatively silent on whether it is possible or necessary to conduct new tests within five years.

However, some important options exist which may mean the

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[261]Reardon, Transcript, November 4, 1975, p. 6.

[262]Section 67503(b)(2) of Proposition 15.

five year deadline is not absolute. If the Legislature were convinced that safety systems were adequate after eight years, for example, the restrictions imposed at the end of five years perhaps could be rescinded.[263] The Legislature could also find only certain types of reactors safe at the end of five years. These approved reactors could then be built in the state. Other reactors which did not originally perform to the satisfaction of the Legislature could keep trying for approval in subsequent years. The Initiative does not require the Legislature to find all reactors of all types adequately safe simultaneously. Exercise of these options may go a long way to making the five year limit more workable.

B. SUBSTANTIVE CRITICISMS

1. Constitutionality.

The largest single question raised about the Initiative is whether the state has any authority to regulate nuclear power plants or if the Federal Government has pre-empted this area of regulation through the Atomic Energy Act. The Supremacy Clause of the U.S. constitution provides that in cases of conflict between state law and federal law, the federal law will prevail--the state law is "pre-empted."[264] The answer to this pre-emption question involves the nature of the operative constitutional clause (e.g., the interstate commerce clause) and the enabling

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[263]This interpretation would probably have to be verified by the courts.

[264]U.S. Constitution, Article VI.

legislation which calls it into operation, as well as the degree, nature, and extent of the state conflict, if any. However it is an area of the law which is ambiguous. Certain aspects of the direct regulation of the use of nuclear power are clearly within an area of federal regulation, while other matters are clearly within the jurisdiction of the state and its political subdivisions.[265] The language in the initiative treads in the gray area between these poles. The Initiative requires land use to be denied (a matter of traditional state jurisdiction) to any nuclear plant which fails to meet certain safety criteria.

The Atomic Energy Act explicitly specifies that under certain conditions areas of regulation of amounts of nuclear materials insufficient to form a critical mass (necessary for sustaining a chain reaction) were delegated exclusively to the states under so-called federal contracts.[266] This dispute comes in what this implies for other areas where there is no explicit pre-emption language. This major reference to explicit state jurisdiction creates problems for those who must find the regulatory distinctions between federal and state jurisdiction. Legitimate inquiries in the form of federal rules, state laws, and litigation have been made relative to this section's effect in state and federal authority, but the section itself is silent in terms of arbitrating and defining expressly the complex interaction and potential conflicts of federal and state regulation.

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[265]Atomic Energy Act of 1954, Ch. 1073, 68 Stat. 919 as amended. Federal-state relations at 42 USC 2018 (1970)

[266]42 USC 2021. (1970).

Thus, the courts have had to arbitrate the conflicts on the basis of implied pre-emption and what they view as the probable legislative intent, the type of development and regulatory scheme contemplated, as well as the legitimate roles of various levels of government.

Statutory and case law ambiguity. It is widely assumed that the clearest area of federal supremacy is in the setting of radiological health and safety standards. When an agency in Minnesota tried to set other standards, a power company took them to court. The court in this case [Northern States Power Co. v. Minnesota, 447 F. 2d. 1143 (1971); affirmed by the U.S. Supreme Court without an opinion 405 U.S. 1035 (1972)] declared the state agency could not set its own standards. The case has been cited as ending the issue of federal pre-emption once and for all.[267] However, the court in this case noted:

> [No provision of the Atomic Energy Act] expressly declared that the Federal Government shall have the sole and exclusive authority to regulate radiation emissions from nuclear power plants.[268]

Nevertheless, the court sided with the argument that congressional silence in the matter of direct radiological standards implied pre-emption.[269] But because there is no definitive

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[267]Murphy & LaPierre. op. cit., p. 86.

[268]Northern States Power Co. v. Minnesota, 447 F. 2d at 1146-47.

[269]The Atomic Energy Act states: "nothing in this section shall be construed to affect the authority of any State or local agency to regulate activities other than protection against radiation hazards" (42 U.S.C. 2021). (1970). From this the court inferred Congress meant to pre-emp the states ability to regulate radiation hazards.

rule of law for interpreting the meaning of implied pre-emption in this situation, there is a chance that another court would come to the opposite conclusion on substantially similar matters. Therefore, the question will probably have to be litigated on a case-by-case basis, with the courts looking at the situation in each case to determine which line of reasoning makes more sense.

Federal administrative waffling. Evidence used in the Northern States Power case indicated the federal bureaucracy was unable to define with certitude the line between state and federal control. For example, Mr. Robert Lowenstein (Office of the General Counsel, AEC) was asked during hearings of the Joint Committee on Atomic Energy in 1959 whether pre-emption should be set forth explicitly in the enabling legislation. He replied:

> ...We considered the desirability of writing the kind of provision you suggest, Mr. Toll, and we decided against it, primarily for the reason that it is practically impossible to define, taking into account all of the various gray areas and special circumstances that might arise where these areas of pre-emption should begin or end (emphasis added).[270]

In the same hearing a letter from the AEC General Manager, A. R. Ludecke, was included:

> ...Our sole purpose was to leave room for the courts to determine the applicability of

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[270]Hearings before the Joint Committee on Atomic Energy on Federal-State Relationships in the Atomic Energy Field, 86th Congress, 1st Session, p. p. 309 (1959).

> particular state laws and regulations dealing with matters on the fringe of the pre-empted area in the light of all the provisions and purposes of the Atomic Energy Act, rather than in the light of a single sentence.[271]

However, even with the ambiguities over pre-emption voiced in these statements, the AEC held to the view that pre-emption was clear and present.

Further judicial confusion: Concurrent state jurisdiction? To add further complications the 10th Circuit Court has found in Colorado Public Interest Research Group v. Train [507 F. 2d. 743 (1974), cert. granted 421 U.S. 998 (1975)] that:

> ...[T]he Federal Water Pollution Control Act Amendments of 1972 grant the federal Environmental Protection Agency authority over the discharge of all radioactive materials including source, by product, and special nuclear materials into navigable waters.[272]

This case was argued before the Supreme Court in December 1975 but has not been decided. If affirmed the case would grant not only joint responsibility between EPA and NRC for radioactive discharges but also would invite concurrent regulation by the state agencies which are delegated federal EPA rulemaking and enforcing capabilities under the Federal Water Pollution Control Act. Any federal supremacy in radiologic standards would therefore be reduced by concurrent state-federal responsibility.

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[270]Hearings before the Joint Committee on Atomic Energy on Federal-State Relationships in the Atomic Energy Field, 86th Congress, 1st Session, p. 500 (1959).

[272]Colorado Public Interest Research Group v. Train, 507 F. 2d. at 743 (1974).

Existing state jurisdiction: Limited or indirectly comprehensive? State and federal law confirm some state role in regulating nuclear powerplants exists. The ability of local governments to exclude nuclear plants through zoning or the Coastal Commission is not challenged. But some threads of legal precedent seem to indicate state jurisdiction may be broader than these limited land use powers. The Atomic Energy Act specifies both state and municipal primacy with respect to the regulation of the generation, sale, or transmission of electricity produced by nuclear power plants.[273] Although this section was undoubtedly directed at rate making and economic regulation by state and municipal utility regulatory bodies (public utilities commissions or boards of municipal utilities) the considerations of plant reliability and public convenience and necessity associated with this type of regulation could open the door to a more comprehensive review. The California Supreme Court in fact indicated the review of public convenience and necessity should be very broadly cast in Northern California Association to Protect Bodega Head and Harbor v. PUC [61 Cal. 2d. 126 (1964)]. In that case the court held that the Federal Government had not pre-empted the issue of the safety of the location of reactors and that the PUC could consider safety questions (e.g. seismic hazards) other than radiation. In addition, William Mitchell, General Counsel of the AEC, testified before Congress in 1954 that a public utilities commission could nullify AEC reoperation of a nuclear

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[273] 42 U.S.C. 2010 (1970).

plant on grounds of public convenience and necessity.[274]

Extent of pre-emption clearly a matter for the courts. Obviously if Proposition 15 passes the issue of pre-emption will again be litigated. Because of the serious ambiguities, it is even difficult to speculate on the ultimate judicial disposition. A study sponsored by the Atomic Industrial Forum, an arm of the nuclear industry, concluded that so-called "moratorium" legislation and initiatives in the states were clearly unconstitutional on pre-emption grounds.[275] Two Stanford law professors concluded though that there is an even chance the Initiative would be found constitutional.[276]

Certain factors may carry considerable weight in any judicial determination. Chief among these factors would be the degree and nature of the state's interest in the particular regulation applied to nuclear power plants, as determined by the courts. The more a particular section is related to a state interest in land use, plant reliability, or public convenience and necessity, the greater the likelihood the section will be sustained, given the present state of the law. Thus certain sections of the

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[274]Hearings before the Joint Committee on Atomic Energy on S. 3323 and H.R. 8862 to Amend the Atomic Energy Act of 1946, 83rd Congress, 2nd Session, pgs. 642-643 (1954).

[275]Bruce & LaPierre, op. cit.

[276]J. H. Barton and C.J. Meyers, "The Legal and Political Effects of the California Nuclear Initiative," Ch. 1 in The California Nuclear Initiative, Stanford University Institute for Energy Studies, April, 1976, p. 26.

initiative may be struck by the courts while others are upheld.[277] There is probably a better chance the courts would declare the safety provisions of the Initiative a legitimate exercise of the State's interest in protecting health and safety rather than other regulatory provisions.

In the last analysis, passage of the Initiative may spur Congress to clarify its intent on pre-emption, resolving the issue by legislative amendment.

In any case, the constitutionality of the provisions of the Initiative is probably irrelevant to the voter's ultimate decision since the area is speculative and does not go to the merits of the issue.

2. Requirement for full accident liability.

As discussed earlier, the Price-Anderson Act limits the liability for damages in the event of a reactor accident to approximately $560 million, while other studies show damages could be as high as $14 billion. Section 67503(a) of the Initiative attempts to force utilities to assume full financial responsibility in case of an accident by threatening to penalize them with the derating of their nuclear plants (to 60% of full power) unless Price-Anderson limits are removed by congressional action or waiver of the limit by June, 1977. Since Congress has recently renewed the Price Anderson Act through 1987 and rejected specific amendments to remove the liability limits,[278] tbe chances of

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[277]The unconstitutionality of one section does not jeopardize the entire Initiative. The Initiative contains a "severability" provision (Sec. 4) which declares the invalidity of one provision will not affect the others.

[278]With the new system of retrospective premiums more than $560 million in coverage may be provided. See supra footnote 189.

federal action to lift the limits in satisfaction of requirements of Proposition 15 are slim. Hence attention has been focused on the waiver mechanism.

Waiver mechanisms difficult but possible. Since the Price-Anderson liability limits have never been waived before, it is unclear how a waiver would work. The operator of a nuclear plant is held harmless by the Federal Government from public liability arising from nuclear accidents in excess of the amount of private insurance available ($125 million now) which the operator carries.[279] The government then indemnifies the public's loss but only to the extent of an addition $435 million beyond that amount, the Federal Government has absolved the operator of liability but provides no additional automatic indemnification. The utitility operator is required to sign an indemnification agreement containing the "hold harmless" provision in order to obtain an operating license for his reactor.[280] Witnesses argued therefore that waiver of the "hold harmless" clause by a utility in order to accept full liability would mean denial or suspension of the utility's operating licenses.[281] They go on to argue that these provisions of the Initiative are impossible to meet regardless of a utility's willingness to assume full liability and thus will force a derating, then a shutdown of all nuclear plants.[282]

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[279] 42 U.S.C. 2210. (1970)

[280] Atomic Energy Act, Section 170a.

[281] Transcript, November 20, 1975, p. 24.

[282] Ibid., p. 115.

There appear to be some ways that are theoretically possible in which liability for damages beyond $560 million could be assumed in satisfaction of the requirements of the initiative, however. Whether these options are in reality possible is unclear. The options require cooperation between the Nuclear Regulatory Commission and the utility.

1. The NRC's indemnification agreement could be modified to allow the reactor operator to assume liability in excess of $560 million if he chooses to do so. This possibility was probably not envisioned when the agreements were originally drafted, but nothing in the law appears to preclude absolutely provisions of this nature. To the extent full liability must also be assured for existing reactors,[283] existing liability and indemnification agreements would have to be amended. The NRC must also amend its rules and regulations to make such a modified agreement acceptable for obtaining an operating license.

2. A utility could file with a California court a statement on the record that the utility agreed to stand liable for any damages in excess of $560 million in the

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[283]Parts of the initiative apply criteria only to new nuclear plants not yet under construction (Section 67503) while others use the same section to apply criteria to existing plants (Sections 67504 and 67506). Probably the authors of the initiative intended Sections 67504 and 67506 to be retroactive but the exact wording is sufficiently cloudy that a court might determine the criteria applied to new plants only.

event of a nuclear accident. The NRC would have to agree that this action would not affect the utility's operating license.

In the case of either of these two options, a California court would be required by the initiative to determine whether full compensation for damages had been assured.[284]

Meaning of "full compensation" unclear. Utilities are also concerned that even if a waiver could be arranged, it would not assure "full" compensation.[285] The utility can pay only to the amount of its insurance plus liquidated assets. For the largest accident calculated, the damages could exceed the utility's ability to pay. But in this case the courts could agree that pledging the assets of the utility would assure compensation as "full" as is assured in any other industry even though there was a slim chance all damages claimed could not be paid.

If waiver not mutually acceptable, court challenge likely. If the NRC and a utility cannot agree on a waiver technique consistent with the Price-Anderson Act, the particular provision of the initiative would be challenged in the courts as unconstitutional. There is no way either a utility or the NRC can be forced to waive the liability limit. The court would probably be unlikely to find a legitimate state purpose in the liability limit removal provisions on which it could declare they are not pre-empted. However, the "hold harmless" and limited liability provisions of the Price-Anderson Act itself may be found unconstitutional if challenged on the grounds that, for damages in excess of the limit, there would be a "taking" without compensation.

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[284] Section 67503(a), Proposition 15.

[285] Transcript, November 20, 1975, p. 115.

3. Idled Plants.

If the liability, reactor safety, and waste disposal criteria of the initiative are not met, operating nuclear plants are not allowed to operate at full power and are gradually phased out. One rationale for such provisions is that reactors which the Legislature cannot agree are safe should not continue to operate. The authors of Proposition 15 could have simply precluded future construction if the Legislature could not make the required finding rather than shutting down operating plants.

By idling plants already built, the capital costs of the plant must be paid for out of revenues for power generated in other plants. Critics of the initiative allege that forcing the utilities to abandon nuclear plants is equivalent to an eminent domain action of the state for which the state must compensate the utilities. Were the courts to agree with this interpretation, the state might have to pay on the order of $3 billion to the utilities. Backers of the initiative find this argument invalid. They feel the derating is not a "taking" which requires state compensation since the action is a legitimate exercise of the "police power" of the state to protect public health and safety.

Eminent domain/condemnation and exercise of the "police powers" are at two ends of a legal spectrum of whether or not compensation is required. The general test is whether a particular action is taken against a specific individual or small number of individuals for a limited public benefit (compensation required) or whether the action affects a large number of persons

and is taken to protect the health and safety of the general public (no compensation necessary). One can readily see how the initiative critics and proponents are trying to argue the derating provisions are closer to one or the other of the ends of this spectrum. It is likely though the court would find these provisions a legitimate exercise of the police power.

C. POTENTIAL ADVERSE SIDE EFFECTS

1. Implications for the Ratepayer.

The initiative could push up the costs of electricity in several ways: (1) through increased costs of electricity generated in plants operating at less than maximum output; (2) through fixed charges on nuclear power plants shut down by the failure of the Legislature to confirm the adequacy of safety and waste systems; and (3) through use of more expensive means for generating electricity as a substitute for nuclear units either delayed or prohibited. While there is nothing in the initiative to prevent the utilities from continuing to build nuclear power plants in the period 1976-1981 so long as the liability and interim safety criteria are met, it seems unlikely that any utility would choose to do so until the final determination had been made by the Legislature in 1981. Continuing to build new plants with no assurances of the final outcome in five years would be very risky for the utilities. Suspending plans to add new nuclear capacity for five years means that the potential cost increases due to deration or shutdown would be greatly reduced, but that

since substitute power plants would be needed the cost penalties due to using more expensive means of generation would potentially be higher.

Assuming the utilities would finish those nuclear plants they now have under construction (and start no more) the total capacity at risk would be approximately 6000 MW out of a state-wide generating base of about 58,200 MW by 1985. Total loss of this capacity would only reduce total capability by 10% in the early 1980's.[286] However, nuclear plants whether partially idle or completely shut down would still have to be paid for by the utility's ratepayers or stockholders.

The larger problem is filling the 15,000 MW gap (through 1990) created by the postponement of nuclear plants pending the Legislature's 1981 decision, or the 36,000 MW gap (through 1995) if the Legislature's judgement is negative and no new construction of nuclear plants is allowed. To fill the gap, four options exist: (1) conservation; (2) solar and geothermal energy; (3) coal and oil-fired plants; and (4) out-of-state nuclear plants. Two federal government-sponsored studies of the effects of the initiative have examined these four options and converted them into costs borne by the utility and have come to very different conclusions.

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[286]However, because nuclear plants are intended to be operating at full power most of the time (base-load), 10% of the capacity would contribute about 15% of the total electricity generated.

A study done by an independent university organization under contract to the Federal Energy Administration[287] concluded conservation would be moderately effective and more solar and geothermal plants would probably be built than the utilities planned. The costs imposed by having to use coal or oil-fired plants were correspondingly reduced. The study included only conservation measures which have already been enacted and await implementation by the State Energy Commission. By 1995, these measures were projected to reduce the need for capacity by 10,000 MW (medium growth case) to over 20,000 MW (low growth case).[288] If load management were to be adopted, the savings would be even greater.[289] The study also believed utilities could be using 5000 MW of geothermal power plants (3258 MW now planned) and 2500 MW of solar power plants or their equivalent in direct residential use (none now included by utilities) by 1995.[290] Subtracting these contributions, the utilities would

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[287]The objectivity of this study was challenged in court shortly after it was started and an independent "oversight" committee was created by the court to ensure objectivity. In addition, the university organization amended the contract with FEA to guarantee the FEA would have no formal authority to decide what was said in the final report.

[288]"Direct and Indirect Economic, Social, and Environmental Impacts of the Passage of the California Nuclear Safeguards Initiative--Executive Summary", Center for Energy Studies, University of Texas at Austin, April 1976, pgs 6 & 7 comparing figures 1 & 2. (Hereinafter cited as CES Report".) No conservation savings shown in the high growth case (6.5% per year growth) which is much higher than utilities now project.

[289]CES Report, p. 11.

[290]CES Report, Main Volume, p. 2C. 5-3.

still be short about 36,000 MW (medium growth) of new capacity by 1995 if nuclear power would be eliminated.[291] For this capacity, the utilities would still have to turn to coal or oil or out-of-state nuclear plants.

Because of the lead times required to build new coal-fired plants and the political problems of mining coal in the Southwest, many of the replacement new units built for the 1980's are likely to be oil-burning. Electricity generated from oil-fired power plants is about 50% - 100% more expensive than electricity coming from a nuclear plant because of the high cost of oil. More coal plants would be coming on line by the late 1980's. The CES Report estimates the cost of generation to be 25% higher for a coal plant than a nuclear plant.[292] The option to build nuclear plants <u>outside</u> California is also available since the preferred sites for many of the planned reactors are near the California-Arizona border anyway. One utility is seriously examining an alternative site across the border for two nuclear units it now plans to build near Blythe. Whether neighboring states would bar this sort of action by the California utilities is an open question. But even if the utilities were successful, there would be an incremental cost penalty for moving the nuclear plants farther from load center due to the higher costs of transmitting the power.

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[291] CES Report, p. 8.

[292] CES Report, p. 33.

Because the use of more coal and oil-fired plants raised the cost of electricity, the FEA study believed consumers would cut back their use in order to avoid higher monthly bills. These actions resulted in lower demand and the need to build fewer coal- and oil-fired power plants--19,000 MW rather than 36,000 MW.[293]

Another study was done internally by the ERDA San Francisco Operations Office [294] and assumed very different conditions. Compared to the FEA study the major features of the ERDA effort are:

1. Conservation is assumed to be not very effective.[295]
2. Two cases are examined with 4% and 5% growth.[296] (Conservation led to 2.5% growth in one FEA study case.)
3. Geothermal power plants by 1995 contribute 3000 MW.[297] (Utilities now plan 3258 MW.)
4. No solar power plants included.[298]
5. Generating costs of coal plants 50% more than nuclear.[299] (FEA study estimated 25%).

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[293]CES Report, pg. 10.

[294]Presented by Donald E. Reardon in written testimony before the California Senate Committee on Public Utilities, Transit, and Energy, February 20, 1976. (Hereinafter cited as "Reardon Report").

[295]Ibid., pgs. 10-11.

[296]Ibid., p. 11.

[297]Ibid., p. 14.

[298]Ibid.

[299]Ibid., p. 21.

6. Consumers do not cut back consumption when faced with higher electricity prices so that demand is not reduced and more oil-and coal-fired plants must be built than estimated in the FEA study.[300]

The two reports combine the higher costs of generation with the unpaid capital costs on idled nuclear plants and calculate the impact of the 20-year loss of nuclear plants on the average family. Both reports agree that electricity prices would increase a maximum of 25-30%.[301] But because of different assumptions and estimates, the ERDA report projects the total cost to be $375 per year for the average family,[302] while the FEA study concludes the cost impact is about $12.50 per year.[303] The costs are on top of the $290 a family and would pay each year for electricity if nuclear power were not constrained.[304] Using out-of-state nuclear plants would result in lower added costs, but neither study included this option in detail.

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[300]Reardon Report, pgs. 22-27.

[301]For a frame of reference, electricity prices have gone up 55% in the last three years (Reardon Report, p. 11).

[302]Reardon Report, p. 27.

[303]Calculated from data in CES Report on p. 19.

[304]The annual bill was 8% higher in 1985 and 4% higher in 1995.

2. Finding Replacement Energy Sources.

With the exception of increased electricity rates, the Initiative would not have noticeable supply effects if non-nuclear power plants can be approved and built in time. Critics of the Initiative argue that if delays are encountered or public opposition to coal-fired or oil-fired power plants grows, shortages could develop. Two periods are important to examine: 1977-1981, when existing nuclear plants might suddenly be derated if the criteria in the Initiative are not met; and 1981-1995 when large base-load coal or oil plants must be brought on line to substitute for nuclear plants either delayed (pending final legislative determinations) or prohibited (if the determination is negative).

In the short term (1977-1981), the utilities appear to have sufficient reserve capacity to absorb the loss of up to 10% of the total installed generating capacity with little difficulty.[305] While this may be true for the state as a whole, though, individual companies may be more severely affected. SMUD for example, will be relying on nuclear power to generate approximately 40-50% of its electricity in this period. Reducing the output of one of their nuclear plants 40% could put a substantial burden on the District to find alternative sources of supply. Also Southern California Edison by the early 1980's will have about 15% of its capacity in nuclear units. While a smaller share of Edison's total output would be at risk compared to SMUD, the actual amount of

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[305]This is also the conclusion of the FEA-funded study of the Initiative: "In 1977 there will be little probability of shortage due to the extent of overcapacity now existing as a result of low demand growth in the last two years." CES Report, p. 48.

energy lost would be much greater since its three nuclear plants would be affected. To equalize any burdens put on the utilities by failure to meet conditions of the Initiative, the utilities themselves could agree to pool power (possibly including pooling with Oregon and Washington utilities) and cover any chronic shortfalls in much the same way as they have now agreed to pool resources in the event of any temporary difficulty. While this may be costly to certain utilities it would prevent serious shortages from developing.

The period around 1981 to 1985 looks more critical. While there is adequate time for utilities to obtain necessary replacements for this period, the utilities could guess wrong on the Legislature's action and be caught off guard or unexpected delays could occur with the first few replacement baseload units already on a tight schedule.[306] Certain small gas turbine power plants are available on relatively short notice (but lead time has grown from 18 to 36 months recently) and emergency power plant construction authorization provisions are contained in state law,[307] so that it is possible to avoid shortages in the early 1980's even if original plans are delayed (at some added cost).

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[306]To have additional new oil-fired plants ready by 1983-1985, utilities must begin to obtain approvals and buy equipment late this year and early 1977. This could be done by moving planned plants up earlier in the current generation resource time table rather than starting from scratch on new plants. However, if the Legislature fails to find nuclear plants safe, SMUD will again be in a serious bind, losing the ability to generate up to 70% of the energy they need in 1983-1985. Consequently SMUD would have to begin planning immediately to construct new non-nuclear plants, to bring on line about 500 MW in 1983-84 and again in 1985-86. Alternatively, SMUD could arrange for power purchase contracts with other utilities to give more time to build new plants.

[307]Public Resources Code Section 25705.

The supply planning situation for the late 1980's and beyond does not look critical. Utilities will have time to develop contingency plans to cope with disappointments just as they do now. If the Legislature declared nuclear power safe in 1981, new nuclear plants would be started in this period and be operational in the early 1990's. If nuclear units are prohibited in California, utilities can choose several options for oil-fired plants, coal-fired plants either inside or outside the state, and perhaps nuclear units in Arizona and Nevada.

The major uncertainties for this longer-term are whether air quality regulations, water supply, and equipment and manpower availability will permit the rapidly expanding mining of coal and its use in power plants and the construction and use of oil-fired power plants. The utilities are concerned that obtaining permission to build fossil fuel-fired power plants will be exceptionally difficult in the future and warn that if they are limited to use of coal and oil-fired plants for the bulk of their expansion, there could be sufficiently serious delays that constraints could be placed on the available power supply. The FEA study notes that uncertainties in the expanded use of nuclear power--limited uranium supply, fuel reporcessing blockages, and shortfalls in enrichment capacity--may constrain its use, also.[308] Uncertainty and risk seem to be an unavoidable cost of doing business for utilities in the next 20 years whether the initiative passes or not.

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[308] CES Report, p. 37.

3. Employment and Economic Growth.

There appears to be a widespread fear that the Initiative will create unemployment in the state and impose hardships on the average family. Much of this fear seems to stem from the belief that the Initiative will bring a halt to the growth in energy use in California[309] or will cause severe energy shortages. According to the analysis in the preceeding sections, the Initiative may result in a modest decline in the rate of growth in energy demand but will not halt it and shortages are unlikely, but possible.

The FEA study concludes: "...[The] maximum impact on gross state product over the twenty year period, 1975-1995, ... was a decrease of 0.03 percent per year in the growth rate... [T]here could be localized, short-term increases in unemployment if nuclear plant construction is suddenly stopped, but the overall long-term economic growth of California would be affected little by the alternative chosen...."[310]

Other sources have been more strident. The Commission for Economic Development, headed by the Lt. Governor, concludes: "The adoption of Proposition 15 ... would substantially inhibit future economic growth in California and would represent a disaster for the working men and women of this state."[311]

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[309] Transcript, Dec. 9, p. 10.

[310] CES Report, p. 29. This conclusion assumes "... alternative energy supplies are available to California when needed, at reasonable prices, and in the quantities required..." (also p. 29).

[311] Statement of the Commission for Economic Development, April 12, 1976.

However, this conclusion was based on a staff analysis which assumed "...dependence upon gas and oil [for electricity generation] will not increase materially in the next twenty-five years,"[312] apparently did not believe new coal plants could be built,[313], and that the utilities would or could do nothing to head off a shortage.[314] It should be noted that utility plans even now call for building more coal- and oil-fired plants (12,200 MW of new capacity) in the next 20 years with no constraints in the use of nuclear energy.[315] Given the CED staff analysis, the utilities would be in serious trouble anyway. The CED staff admits its estimates "are at best guesswork". [316] Given the range between the CED estimate and the more sophisticated FEA study, it appears the CED staff greatly exaggerated the potential economic and employment effects of the Initiative.

4. Environmental degradation.

Generating electric power regardless of the energy source used degrades the environment to some extent. If conservation and the use of solar and geothermal energy are insufficient to meet the slack created by delaying or prohibiting nuclear

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[312] Letter from Steven E. Smith, Executive Director, Commission for Economic Development to the Commissioners, April 2, 1976, pgs 11-12. (Hereafter cited as "CED Staff letter".)

[313] Ibid., p. 13.

[314] Ibid., p. 13.

[315] See p. 8 of this report.

[316] CED Staff letter, p. 17.

plants, and fossil fuels must be used, will there be more environment degradation than if nuclear were unconstrained? Unfortunately, the environmental consequences of using either nuclear energy or fossil fuels are potentially large but unknown. Moreover, the impacts are much different in character and hard to compare in order to know how much of one impact is equivalent in consequence to another. Ted Taylor, for example, testified that so little is known about the ultimate costs of using either fossil fuels or nuclear energy that neither alternative may be acceptable,[317] making conservation more attractive.

Most of the attention on the adverse environmental consequences of burning fossil fuels has focused on the shorter term impacts on the health of the nearby residents. But throwing sulfur oxides, carbon dioxide, particulates, and a host of other toxic materials into the air have their long term implications just like the long-term dilemma of radioactive wastes. The build-up of sulfur compounds in the air can turn the rain acid. The continued release of carbon dioxide can, through a greenhouse effect, raise the average temperature of the earth. In each of these cases fundamental processes which make the planet habitable are being altered. The outcome is unknown, but it affects many generations yet to come.

The short-term impacts which are widely recognized include problems in extraction (oil spills, strip mining) and use (air pollution). The direct effects of air pollutants from fossil fuel combustion on human health are known to be

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[317]Transcript, December 10, 1975, p. 3.

serious but are poorly understood compared to the large amount of information which has been accumulated on the consequences of exposures to radioactive substances. For example, it is known that sulfur oxides cause a very severe form of emphysema, but there is a huge controversy about how many people die in the United States each year as a result of breathing sulfur-contaminated air from coal-burning power plants.[318] Information is just being developed on the magnitude of the risk posed by living in the air polluted by large conventional power plants.

The problem of salvaging lands disrupted by the surface mining of coal is national in scope. In 1970 about 1.5 million acres of land had been strip-mined for coal, two-thirds of which were listed as unreclaimed.[319] In the arid lands of the west, the removal of the thin soil cover and the loss of soil moisture may make reclamation very difficult--and expensive--in providing coal for California. Without reclamation the western lands are subject to high erosion and give the appearance of a wasteland.

Oil spills generally have a highly disagreeable but localized impact. The serious consequences of a spill come in the damage it does to marine life. However, the amount of oil spilled may be small in comparison to the amount intentionally discharged.[320]

In contrast to fossil fuels, concern over nuclear power seems to focus on long-term impacts--reactor accidents and the latent

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[318]Taylor, Transcript, December 10, 1975, p. 15.

[319]Michael Fortune, "Environmental Consequences of Extracting Coal" in Energy and Human Welfare: The Social Cost of Power Production ed. by Barry Commoner, Howard Boskenbaum and Michael Corr (Macmillan: New York, 1975) p. 44.

[320]J.D. Porricelli, et al., "Tankers and the Ecology", Trans. Soc. Naval Arch. & Marine Eng., Vol. 29, 1971, Figure 1.

production of cancer and genetic defects, waste disposal and the chance of accidental release hundreds of years later. In order to say whether fossil fuel use is more hazardous, one must compare sulfur dioxide as a contaminant to radiation, strip mining to reactor accidents, climate modification to nuclear waste disposal, and so forth. One must also know for each kilowatt-hour how much of each impact is produced. This task involves measuring not only the amounts of pollutants exiting the stacks of a coal-burning powerplant, but also the probabilities of reactor and waste storage accidents and their consequences. As Chapter 3 pointed out these latter estimates are contested. The university witnesses who testified could come to no agreement on how these relative assessments should be done.

For example, three researchers at Berkeley focused on the comparative health impacts of various power plants--waste disposal, air, land, and water impacts of fuel extraction, and the indirect, long-term effects of pollutants were all ignored.[321] The study was limited to the death and disease caused (1) by routine emissions from operating power plants, (2) by major accidents, and (3) by extracting fuels (focusing on workers' health). The comparison was on the numbers of days lost to illness per year of plant operation per megawatt of plant capacity (a death was assumed to be the equivalent of 6000 lost days, an average loss of 16 years of life). They calculated a typical coal plant is responsible for about 150 to 1200 lost days

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[321] Kirk Smith, et al., "Evaluation of Conventional Power Systems", Energy and Resources Group, University of California, Berkeley, 1975.

per megawatt-year, an oil-fired plant, 30-1200 lost days, and a light water reactor 1-75 lost days.[322] For the coal and oil plants, the normal air pollutant emissions were responsible for most of the lost days. For the nuclear plant, the figure was dominated by an averaged annual risk of a very large, but very low probability accident.

These figures do not put an end to the debate because (1) the risks from fossil fuel use can be reduced through use of better emissions control techniques, and (2) a different assumption can be made on the number of days lost per death not to mention disputes over the ignored impacts, the long-term effects, and whether "days lost" is an appropriate measure. So a proponent of nuclear power can emphasize the low range of the impact of a reactor (1 day lost) compared to the perhaps 1000-fold greater impact of a coal-fired plant. A critic of nuclear power, though, can contend fossil fuels can be used with fewer emissions[323] (bringing the days lost down to perhaps 10-15) but the accidental potential of reactors because of basic human fallibility will be large [75 days lost or (if deaths are valued at 12,000 days lost) 150 days lost]. The analysis has done little to narrow the range of disagreement.

The correct answer therefore, to the question of whether the Initiative, to the extent it results in more fossil fuel use, will mean more environmental damage, is that no one knows. The

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[322] Kirk Smith, et. al., "Evaluation of Conventional Power Systems", Energy and Resources Group, University of California, Berkeley, 1975. Figures 5-7.

[323] Barry Commoner takes this approach, p. 36, Transcript, December 10, 1975.

backers of the Initiative, one can infer, suspect nuclear power presents the greater hazard. Many can be found with the opposite view.

CHAPTER SIX

OTHER MECHANISMS FOR REASSESSMENT

Assuming some sort of reassessment is necessary, the wisdom of Proposition 15 can be judged by comparing it to other means available in the state, what sort of reassessment these means would accomplish, and the costs they would impose. The principal alternatives in the state appear to be actions by the State Energy Resources Conservation and Development Commission, based on existing authority and mechanisms established by legislation.

Critics of the Initiative characterize its provisions requiring a derating, and prohibiting new plants in certain circumstances, as unnecessarily stringent. Initiative proponents, however, appear convinced stringent measures are necessary to make the nuclear industry, the NRC, and ERDA take public concern seriously. The proponents seem to believe these three groups have been too complacent. The major alternatives to the Initiative would probably not be as stringent.

Energy Commission could conduct reassessment but authority limited.

The Energy Commission came into being in 1975 and regulates power plant siting and energy conservation in the state. If it desires, it could do a review of nuclear safety and set some conditions on approval of nuclear power plants (Public Resources Code Section 25511). The commission does not have clear and explicit authority to condition its approval on demonstrations of waste

disposal safety or reactor safety, but the same problems could be addressed indirectly through reviews of the economics and reliability of the plant and through specific siting criteria (minimum distance from populated areas, minimum distance from active faults). The commission would probably have to set these conditions on a case-by-case basis, though. However, there would be no legal impediments to the commission conducting a generic review of nuclear safety without necessarily tying any of its findings into explicit conditions for approval of siting applications. But also the commission could probably not force certain safety tests to be done.

The major differences between this mechanism and the Initiative are:

(1) The commission could conduct its review over a period of time greater than five years but would probably site nuclear plants in the interim.

(2) The commission could not affect the seven nuclear plants now operating or under construction or which are grandfathered outside its jurisdiction. It could only deal with those plants which need commission permission to begin construction. It would not have the ability to impose any retroactive sanctions which Initiative proponents believe are necessary.

(3) The commission could do little to assure full accident compensation.

While reassessment by the Energy Commission is a possibility, there have been no indications the commission intends to conduct such

a review or has any inclinations or budgeted capability to do so in the near future. In fact, three of the five commissioners have expressed pro-nuclear positions in public. Therefore, the viability and efficacy of this option is questionable.

Legislation could establish new authority. One valid criticism of the Initiative is that it contains some ambiguous and procedurally burdensome provisions (although given certain interpretations they are workable). Legislation provides the opportunity to work out provisions which avoid certain pitfalls. Clearly, the Legislature could structure a reassessment either more stringent than the Initiative or less stringent. The Legislature would not be encumbered like the Energy Commission, by existing state law.

Four nuclear bills introduced by Committee. Based on its findings from the hearings on the Initiative, the Committee introduced four pieces of legislation (AB 2820-2823) designed to achieve in part and to supplement the goals of the Initiative. The bills have as their subjects adequate fuel reprocessing capacity (AB 2820), undergrounding of reactors (AB 2821), permanent waste disposal adequacy (AB 2822), and fuel accident liability (AB 2823). The liability bill (AB 2823) was defeated in the Assembly Ways and Means Committee. The remaining three passed the Assembly and are now before the State Senate.

The bills are designed to provide a pause in the deployment of nuclear power plants until (1) certain stipulated problems which may "clog" the nuclear fuel cycle are resolved (AB 2820

and AB 2822) and (2) a study is conducted to determine if an extra margin of safety can be feasibly attained by putting reactors underground (AB 2821).

The fuel cycle bills are similar in design. The capability to reprocess spent nuclear fuel and the ability to dispose of (permanently store) high level radioactive wastes are required to be addressed and resolved by the federal government, to the satisfaction of the State Energy Commission, before any new nuclear plants can be certified. The commission's decision must be ratified by the Legislature within one year. These are generic determinations that the technology exists for reprocessing and for waste disposal. On a case-by-case basis the Commission must also find that sufficient reprocessing capacity or spent fuel storage is available before permitting a specific nuclear plant to be built. This specific finding will not be submitted to the Legislature for ratification.

The third bill (AB 2821) requires that up to a one-year study be conducted on the costs and benefits of undergrounding or "berm containing" (placing the reactor in a scooped out hole and backfilling with dirt) nuclear power plants to increase the margin of safety in the event of an accident which breaches the containment building. Pending the results of the study, no new nuclear plants can be certified by the commission. If the commission determines that such techniques are not feasible or justifiable, the pause in certifying nuclear plants continues for an additional year to allow the Legislature to evaluate the

results of the study, to conduct its own analysis, and to provide for an undergrounding or berm containment siting policy by statutory enactment.

Relationship of the bills to the Initiative. The bills are considered to be not as strict as the Initiative in their requirements. The current major distinguishing features of the bills vis-a-vis Proposition 15 are:

1. Only new construction is prohibited unless certain conditions are met. Existing plants are unaffected.
2. Through a grandfather (or exemption) clause, four nuclear units can be built without meeting the criteria the bills impose.
3. The Energy Resources Conservation and Development Commission is made the operative body (rather than the Legislature), but at least the generic findings of the Energy Commission must be affirmed in a simple majority vote of both houses of the Legislature. The deliberations both by the Commission and by the Legislature are to be done in an open public forum.
4. Reactor safety per se is not addressed by the bills.
5. Waste disposal safety is not directly addressed by the bills, which ask only that a method be chosen and accepted by the federal government.
6. Limited accident liability is unaffected (since AB 2823 failed passage).

7. Pending the final determinations of the Commission and the Legislature, applications to the Energy Commission to build new nuclear plants may be processed up to the point of final commission approval. This provision reduces the time to begin construction on new plants, when and if the appropriate findings are made.
8. No time limit is imposed on the commission's findings that reprocessing and waste disposal techniques exist.

The bills, therefore, do not substitute fully for the Initiative. However in some ways, the bills complement the Initiative. If both Proposition 15 and the bills should be enacted, there would be no conflicts between them. However, some provisions may overlap and be redundant.

The existence of the Initiative has created an atmosphere to take immediate action (passing the bills) which avoids some negative side effects and which may be more acceptable. The existence of the bills has somewhat clouded the choice to me made on the Initiative. Some argue that the Initiative should be voted down because the existence of the bills indicates the Legislature will act anyway. However, if the Initiative fails and the bills have not passed, the impetus which makes the bills attractive would fade. As a result, the bills would probably never be enacted either. To avoid this dilemma, the Committee has agreed to push the three-bill package to a conclusion--either enactment or defeat--<u>before</u> the primary election in order that the voter know clearly whether alternatives to the Initiative exist.

Even though theoretically there are alternatives, it is unlikely a mechanism as strongly resisted by the nuclear industry and the federal regulatory and promotional agencies or as strongly supported by the environmentalist and anti-nuclear factions in this state will be established.

APPENDIX

TEXT OF PROPOSITION 15

This initiative measure proposes to add a Title 7.8 to the Government Code. It does not amend any existing law.

PROPOSED LAW

Sec. 1. Title 7.8 (commencing with Section 67500) is added to the Government Code, to read:

TITLE 7.8 LAND USE AND NUCLEAR POWER LIABILITY AND SAFEGUARDS ACT

67500. This title shall be known and may be cited as the Nuclear Safeguards Act.

67501. The people and the State of California hereby find and declare that nuclear power plants can have a profound effect on the planning for, and the use of, large areas of the state, as do related facilities connected with the manufacture, transportation, and storage of nuclear fuel, and the transportation, reprocessing, storage, and disposal of radioactive materials from nuclear fission power plants.

67502. The people further find and declare that substantial questions have been raised concerning the effect of nuclear fission power plants on land use and land use planning, as well as on public health and safety. Such questions include, but are not limited to, (a) the reliability of the performance of such plants, with serious economic, security, health, and safety consequences; (b) the reliability of the emergency safety systems for such plants; (c) the security of such plants, and of systems of transportation, reprocessing, and disposal or storage of wastes from such plants from earthquakes, other acts of God, theft, sabotage, and the like; (d) the state of knowledge regarding ways to store safely or adequately dispose of the radioactive waste products from nuclear fission power plants and related facilities; and (e) the creation by one generation of potentially catastrophic hazards for future generations.

67503. A nuclear fission power plant and related facilities may be a permitted land use in the State of California and its waters and considered to be reasonably safe and susceptible to rational land use planning, and may be licensed by state or local agencies, and may be constructed in the state only if all of the following conditions are met:

(a) after one year from the date of the passage of this measure, the liability limits imposed by the federal government have been removed and full compensation assured, either by law

or waiver, as determined by a California court of competent jurisdiction and subject to the normal rights of appeal, for the people and businesses of California in the event of personal injury, property damage, or economic losses resulting from escape or diversion of radioactivity or radioactive materials from a nuclear fission power plant, and from escape or diversion of radioactivity or radioactive materials in the preparation, transportation, reprocessing, and storage or disposal of such materials associated with such a plant; and

(b) after five years from the date of the passage of this measure.

(1) the effectiveness of all safety systems, including but not limited to the emergency core cooling system, of any nuclear fission power plant operating or to be operated in the State of California is demonstrated, by comprehensively testing in actual operation substantially similar physical systems, to the satisfaction of the Legislature, subject to the procedures specified in Section 67507; and

(2) the radioactive wastes from such a plant can be stored or disposed of, with no reasonable chance, as determined by the Legislature, subject to the procedures specified in Section 67507, of intentional or unintentional escape of such wastes or radioactivity into the natural environment which will eventually adversely affect the land or the people of the State of California, whether due to imperfect storage technologies, earthquakes or other acts of God, theft, sabotage, acts of war, governmental or social instabilities, or whatever other sources the Legislature may deem to be reasonably possible.

67504. (a) If within one year from the date of the passage of this measure the provisions of subsection 67503(a) have not been met, then each existing nuclear fission power plant and such plants under construction failing to meet the conditions specified in subsection 67503(a) shall not be operated at any time at more than sixty per cent of the original licensed core power level of such plant.

(b) Beginning five years from the date of the passage of this measure, each existing nuclear fission power plant and each such plant under construction shall not be operated at any time at more than sixty per cent of the licensed core power level of such plant and shall thereafter be derated at a rate of ten per cent per year of the licensed core power level of such plant, and shall not be operated at any time in excess of such reduced core power level, unless all of the conditions enumerated in Section 67503 are met.

67505. The provisions of Sections 67503 and 67504 shall not apply to small-scale nuclear fission reactors used exclusively for medical or experimental purposes.

67506. One year from the date of the passage of this measure, the Legislature shall initiate the hearing process specified in Section 67507, and, within three years from the date of the passage of this measure, determine whether it is reasonable to expect that the conditions specified in Section 67503(b) will be met. Unless the Legislature determines that it is reasonable to expect that the conditions of Section 67503(b) will be met, then nuclear fission power plants shall be a permitted land use in California only if such existing plants and such plants under construction are operated at no more than sixty per cent of their licensed core power level. Unless the determinations specified in this section are made in the affirmative, then neither the siting nor the construction of nuclear fission power plants or related facilities shall be a permitted land use in California.

67507. The determinations of the Legislature made pursuant to subsection 67503(b) and Section 67507 shall be made only after sufficient findings and only by a two-thirds vote of each house.

(a) To advise it in these determinations, the Legislature shall appoint an advisory group of at least fifteen (15) persons, comprised of distinguished experts in the fields of nuclear engineering, nuclear weaponry, land use planning, cancer research, sabotage techniques, security systems, public health, geology, seismology, energy resources, liability insurance, transportation security, and environmental sciences; as well as concerned citizens. The membership of this advisory group shall represent the full range of opinion on the relevant questions. The group shall solicit opinions and information from responsible interested parties, and hold widely publicized public hearings, after adequate notice, in various parts of the State prior to preparing its final report. At such hearings an opportunity to testify shall be given to all persons and an opportunity to cross-examine witnesses shall be given to all interested parties, within reasonable limits of time. The advisory group shall make public a final report, including minority reports if necessary, containing its findings, conclusions, and recommendations. Such report shall be summarized in plain language and made available to the general public at no more than the cost of reproduction.

(b) To ensure full public participation in the determinations specified in subsection 67503(b) and Section 67506, the Legislature shall also hold open and public hearings, within a reasonable time after the publication of the report specified in subsection (a) of this section, and before making its findings, giving full and adequate notice, and an opportunity to testify to all persons and the right to cross-examine witnesses to all interested parties, within reasonable limits of time.

(c) All documents, records, studies, analyses, testimony, and the like submitted to the Legislature in conjunction with its determinations specified in subsection 67503(b) and Section 67506, or to the advisory group described in subsection (a) of this section, shall be made available to the general public at

no more than the cost of reproduction.

(d) No more than one-third of the members of the advisory group specified in this section shall have, during the two years prior to their appointment to the group, received any substantial portion of their income directly or indirectly from any individual, association, corporation, or governmental agency engaged in the research, development, promotion, manufacture, construction, sale, utilization, or regulation of nuclear fission power plants or their components.

(e) The members of the advisory group shall serve without compensation, but shall be reimbursed for the actual and necessary expenses incurred in the performance of their duties to the extent that reimbursement is not otherwise provided by another public agency. Members who are not employees of other public agencies shall receive fifty dollars ($50) for each full day of attending meetings of the advisory group.

(f) The advisory group may:

(1) Accept grants, contributions, and appropriations;

(2) Create a staff as it deems necessary;

(3) Contract for any professional services if such work or services cannot satisfactorily be performed by its employees;

(4) Be sued and sue to obtain any remedy to restrain violations of this title. Upon request of the advisory group, the State Attorney General shall provide necessary legal representation.

(5) Take any action it deems reasonable and necessary to carry out the provisions of this title.

(g) The advisory group and all members of the advisory group shall comply with the provisions of Sections 87100 through 87312 inclusive, of Title 9 of the California Government Code.

(h) Any person who violates any provision of this section shall be subject to a fine of not more than ten thousand dollars ($10,000), and shall be prohibited from serving on the advisory group.

67508. (a) The Governor shall annually publish, publicize, and release to the news media and to the appropriate officials of affected communities the entire evacuation plans specified in the licensing of each nuclear fission power plant. Copies of such plans shall be made available to the public upon request, at no more than the cost of reproduction.

(b) The Governor shall propose procedures for annual review by state and local officials of established evacuation plans,

with regard for, but not limited to such factors as changes in traffic patterns, population densities, and new construction of schools, hospitals, industrial facilities, and the like. Opportunity for full public participation in such reviews shall be provided.

Sec. 2. There is hereby appropriated from the General Fund in the State Treasury to the legislative advisory group created by Section 67507 of the Government Code the sum of eight hundred thousand dollars ($800,000) for expenditures necessary in carrying out the responsibilities and duties set forth in Section 67507 of the Government Code.

Sec. 3. Amendments to this measure shall be made only by a two-thirds affirmative vote of each house of the Legislature, and may be made only to achieve the objectives of this measure.

Sec. 4. If any provision of this measure or the application thereof to any person or circumstances is held invalid, such invalidity shall not affect other provisions or applications of the measure which can be given effect without the invalid provision or application, and to this end the provisions of this measure are severable.