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ON THE USEFULNESS OF QUANTITATIVE SAFETY GOALS FOR STATE REGULATION OF ENERGY SYSTEMS

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Summary

The potential usefulness of quantitative safety goals for energy systems in the State of California is evaluated. Five energy-related risk issues, previously dealt with by state regulatory agencies, are examined for the role played by risk in decision-making and the possible role that quantitative safety goals might have played. Several other energy-related risk situations are identified and briefly discussed. It is concluded that quantitative safety goals do not appear to be needed for risk management of energy systems in California. However, there does appear to be a role for a central office of risk management in the State governmental structure. Such an office would provide a reference and evaluation service for other agencies. The potential usefulness of establishing threshold levels of risk for different kinds of action is also noted.

1. Introduction

Society is becoming increasingly aware of the fact that risks accompany the benefits and the other costs of its technological ventures, especially those related to energy production.

These risks cannot be totally eliminated; they can only be managed, and they are only one of many sets of issues which must be considered in the decision process. Uncertainties arise in the technical estimation of both risks and benefits, and, in addition, differences among individuals in the assignment of values result in controversies over the evaluation of risks and benefits. The field of risk acceptance has been reviewed by the works of Lowrance [1], and Rowe [2], among others. An example of a study which examines the risks from several energy sources is that of the National Academy of Sciences [3]. Some legal perspectives have been provided by Green [4].

Considerable costs to society arise from the conflict over accepting technological risks: examples include anxiety and dismay due to conflicting information; litigation costs; retrofits; and misplaced investments and costly delays that result from industry's inability to predict public risk acceptance or to plan for regulatory requirements [5].

Management of risks is at least as much a socio-political problem as it

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is a technical one. It is difficult in that it is intrinsically multi-disciplinary. Some of the multi-disciplinary aspects are investigated in a report of work done for the National Science Foundation at UCLA [6]. An important question that arises is, "How safe is safe enough?", given the other costs and benefits of the technological undertaking. Attempts to answer this question frequently employ some combination of historical precedents implied by past regulatory decisions or by statistics on a wide range of human risks [2, 7], and psychometric surveys concerning societal perceptions and evaluations of risk [8], and a broad set of economic, sociological and political factors. Because of the trade-offs involved in the economic, socio-political and technical decisions to undertake or not to undertake a large technological venture, the question "How safe is safe enough" will not be subject to a unique answer.

The realization that society as a whole has limited resources that can be expended for risk reduction has led to concern over the cost-effectiveness of safety measures. There exists a large variation in the levels of risk imposed upon society by various technologies [6] and in the amount of money allocated to reduce these risks [9, 10].

Various approaches have been proposed to determine whether a technological system is safe enough; these include professional judgment, cost–benefit analysis, comparison with background hazards, revealed preferences, and comprehensive analysis of various options in a decision theory framework. Each has its advantages and disadvantages [11].

At the federal level, there exists a growing trend toward the quantification of risk and the use of comparative risks as one important input into the regulatory process. The House Committee on Science and Technology, in its 1979 National Science Foundation (NSF) Authorization Report, observed that the ability to assess and balance risks is well behind regulatory needs and encouraged NSF, to the extent possible, to develop a program of systematic research on comparative risk analysis. In October 1980 the Nuclear Regulatory Commission (NRC) issued a plan for developing a safety goal to be used in defining more clearly the level of protection for the public health and safety that it believes is adequate for safe reactor operation. In March, 1983, the NRC published a safety policy statement which includes quantitative objectives.

Much less is being done at the state level in many, if not most, states. A research project, sponsored by the National Science Foundation [12] and completed recently at UCLA, has investigated current practices at the state and local level with regard to the management of risk to public health and safety. A fundamental finding is that a quantitative grasp of risk is sometimes lacking in state governments and frequently is absent in local government. The information that is available to society as a whole is frequently not part of the background of responsible local officials, and the concept of managing risk to reduce ill effects on health and safety is sometimes foreign to local governments which are organized to respond only to crises. There are, of course, exceptions. For example, Michigan has recently proposed adopting a quantitative lifetime risk of cancer of 10^{-5} from the use of drinking water and the consumption of fish [13].

In this study we examine the question "In view of a growing trend toward the use of quantitative risk assessment and even the establishment of quantitative safety objectives, would it be useful to develop and apply quantitative risk assessment techniques and safety objectives in the regulation of energy systems in California"?. To help gain a perspective, we decide to first examine several specific energy-related risk issues in which state regulatory groups have recently acted or developed documented positions. Five case studies are identified and evaluated for the similarities and differences in approach, the nature of the risk involved, and the extent that quantification is or may be useful. A few other energy-related risk situations are then identified and briefly discussed to see if they provide any additional perspective.

With the aid of the case studies, and the benefit of prior studies on the use of quantitative safety objectives elsewhere, as well as studies on risk management at the state and local level, some tentative conclusions are drawn in the final chapter concerning the usefulness of a more quantitative approach to safety.

2. Summary of case studies

Five brief case studies have been performed, as follows:

- Gas pipeline safety
- Geysers Unit 20 — A new geothermal power plant
- Safety and Insurance Requirements of QFs (Qualifying Facilities)
- The risk management plan of the Ports of Los Angeles and Long Beach
- Energy conservation measures and indoor air pollution

These case studies represent the available recent issues in which a state agency has reached a documented position. The safety approach for each of the five is summarized below. A more extensive discussion is to be found in the Appendix.

2.1 Gas pipeline safety [14]

The achievement of gas pipeline safety involves a partnership between the federal government and the states, with the Public Utilities Commission (PUC) acting for the State of California. Safety is achieved primarily by standards for construction, by continuing inspection, and measures to prevent incidents of damage to buried pipelines from excavation, etc. Neither the federal nor the state government employ quantitative safety criteria; however, the pipeline safety record in the U.S.A. in recent years is very good. Nevertheless, it is not impossible that a pipeline leak in an urban area might lead to a catastrophic accident. It is not clear that quantitative estimates of the frequency of such a "rare event" exist, nor whether its possibility merits special measures.

It is of interest to note that pipeline accidents do, on occasion, lead to severe events. The Los Angeles Times on February 26, 1984 reported that a leak in a gasoline pipeline running under a Brazilian slum led to a fire killing more than 80 people. This was later reported on the television news to have involved 500 to 600 fatalities; the damage was very severe and early estimates were grossly in error.

2.2 Geysers Unit 20 [15]

This proposed new geothermal plant is regulated by the California Energy Commission (CEC). CEC has concluded that Geysers Unit 20 complies with all applicable air quality standards, thus assuring protection against deleterious effects of regulated pollutants, since air quality standards are based in part on the protection of public health. CEC requires monitoring of unregulated pollutants, such as arsenic, which may be carcinogenic. CEC has also examined the handling and storage of hazardous, toxic or flammable materials at the plant and has found that adequate protection would be provided.

It does not appear that the Geysers 20 plant affords any substantial risk to the public. However, no quantification of the risk inherent in meeting the air standards, etc. is provided. Rather, as with the pipelines, meeting the relevant standards is taken as an adequate assurance of safety.

2.3 Safety of Qualifying Facilities (QFs) [16]

QFs are small power production facilities which "qualify" under the law to sell their excess electricity generation to the electric utility companies. One risk posed by QFs is that downed utility lines may continue to be energized by the QF due to failure of the protective device, thereby creating the hazard of electrocution for a utility repairman or a member of the public. Two or three utilities had required low-power QFs to pay for expensive insurance premiums, which threatened the economic viability of the venture.

In the view of the Public Utility Commission (PUC), interconnection of utilities with QFs is safe enough when three specified major functional standards are abided by and the QF provides adequate protection against specified adverse conditions. PUC determines how safe is safe enough by the historical records (no reported injuries in a few years of such operation) and its judgment on the effectiveness of required safety equipment. Very small ($<$ 20 kW) QFs should not need to pay for liability insurance.

The utilities appear to wish even stricter safety standards, as well as more stringent liability requirements. Neither the utilities nor the PUC appear to have used quantitative risk estimates or goals in establishing their preferred position. Whether the risk to linesmen is being significantly increased remains to be ascertained in the future.

2.4 Risk management plan for the Ports of Long Beach/Los Angeles [17]

The California State Coastal Commission has required a three-phased study leading to development and implementation of a risk management plan for the Ports of Long Beach and Los Angeles. Phase 1 is an inventory of where hazardous materials are stored or transported. Phase 2 involves an analysis of the risk to people and facilities. Phase 3 combines these into an implementation plan. The risk management plan does not involve backfitting existing facilities or facilities already under construction.

The general approach used in laying out a risk management plan is to identify ' hazard footprints", i.e., an outline drawn on a map around each facility within which unacceptable effects could occur should an accident take place at the facility. Nominally "worst-case" conditions are to be used in determining distances beyond which impacts of an accident are acceptable.

Once "footprints" are determined, future facilities will be located accordingly. Modifications or expansions of existing facilities will fall under the same requirements.

The guidelines seem to allow the assessment of specific case hazards in terms of accident possibilities, with an eye to how severity of probability or damage could be reduced. They also permit exceptions to be made in the circumstance of "overriding considerations", including the situation where some risks are premised on highly improbable events, and where denial of a development permit is not in the public interest. No quantitative guidance is provided for the term "highly improbable".

2.5 Energy conservation measures and indoor air pollution [18, 19]

Both the Public Utilities Commission (PUC) and the California Energy Commission (CEC) are involved in measures involving energy conservation in homes and business establishments. The PUC, for example, has been rather careful in examining the fire-resistance and toxicity of proposed insulation materials.

The PUC has approved zero-interest financing by Pacific Gas & Electric (PG & E) of homeowner programs of conservation, including weather-stripping and caulking to reduce the rate of heat loss. The possible adverse health effects due to increased air pollution with a reduction in the rate of air exchange of a house that could accompany weather-stripping and caulking appear to have been neglected by PUC in taking the above action.

The CEC has noted possibly adverse effects from increased indoor air pollution associated with the originally proposed CEC standards for energy conservation in future homes. Some modification of the standards has resulted, but they are still estimated to result in a 30% reduction in air exchange rates for new residences. The CEC staff has not quantified what the current risk from indoor air pollution is or what the societal consequences of a 30% reduction in air exchange would be. Other facets of the problem relate to the possible use of recirculated air in industrial buildings without requirements on cleanup.

Publications by Nero [2], Spengler and Sexton [21] and Hurwitz [22], among others, point out the potentially very considerable health risk which may result from current indoor air pollution levels, and which could be exacerbated by significant reductions in air exchange rates.

Hurwitz [22] has estimated that an average reduction of 20% in air infiltration may lead to an additional lifetime risk of lung cancer of 200 per million people exposed due to the extra build-up of radon. Other indoor pollutants would add to such a risk. Larger reductions in air infiltration would lead to total risk from indoor air pollution which are non-negligible compared to that of death annually from automobile accidents (250 per million people).

It is of interest to note that estimates of the lifetime risk of cancer associated with normal exposure to indoor radon range from 0.1% to 0.4%. (This compares to a lung cancer incidence in non-smokers of 0.6% to 1%.)

The issue of indoor radon is examined in further detail in the Appendix.

3. Some other energy-related risk situations

The five case studies were chosen primarily because of the existence of a position on the matter by a state regulatory group. Herein, we generate a short list of some other energy-related risk situations and examine them briefly to see if they introduce markedly different attributes.

3.1 Coal-fired and oil-fired electricity generation

Both coal and oil introduce hazards in their production and transportation to the central station, electric-generating facility which consumes them. Oil burning leads to significant effects on air quality and hence health; coal is probably much worse than oil in this regard, if an equal number of people is exposed to the effluents. It must be noted that there remains considerable disagreement among the experts as to whether excess mortality rates have been demonstrated as having been caused by such effluents. Completely rigorous epidemiological studies are very difficult to perform [3]. However, there appears to be no basis to completely discount those studies which find large health effects from the combustion effluents. And, clearly, if one performed risk analysis in terms of each of the many components in the effluent gases, in the same manner as is done for low-level radiation, significant societal health risks could be calculated. Coal also introduces societal risks of water contamination both from the residue of mining activities and from the solid waste products of combustion.

The acid-rain matter, of course, is a current international controversy.

Quantitative safety goals are not used nationally or on a state-wide basis in regulating fossil-fuel, electric-generating plants, and the regulatory authorities generally do not discuss incurred societal risks. Rather, reference is usually made to the limits imposed by the Clean Air Act. The existing large uncertainties in health effects make it very difficult for State Regulatory groups to be any more quantitative as to what air pollution actually means to health. The resources needed to quantify such health effects are far beyond those of the States.

3.2 Co-generation

The use of fossil combustion to provide both electricity and process heat (such as space heating) is growing. It frequently implies combustion in more urban areas where a new coal or oil-fired, central-station electricity-generating plant would not be allowed. It is not clear how any incremental adverse health effects which might result are assessed, beyond keeping within the relevant air quality standards (which are not risk-free).

3.3 Wood-burning stoves

The use of wood-burning stoves has grown markedly during the past decade, with little regulatory attention being given to the possibly rather significant health effects which might result from increased indoor air pollution [21]. Quantifying such risk would be very difficult, however.

3.4 Hydro-electric dams

Since the San Fernando earthquake in 1971, the State of California has undertaken a safety review of the dams for which the State has regulatory authority. While the California Division of Safety of Dams appears to have rather stringent standards it does not quantify publicly what it means when it makes a finding that a dam is "safe". Any balancing of cost, risks, economic benefits, and sociological and political considerations appears to be done by the decision makers in the Division of Safety of Dams without the benefit of public input into the process or knowledge of the risks adopted on their behalf.

3.5 Liquified natural gas

By statute, the State of California has adopted very stringent requirements for any proposed LNG importation facility, seemingly far more stringent than is implied for existing LNG facilities in Massachusetts or Maryland, for example. In particular, the statute tends to use a "footprint" approach and limits the number of people who could be living within the affected zone. Thus, it imposes a limit on societal risk; however, the risk to the relatively few individuals living near such a facility is not regulated to be below some quantitative goal.

This legislative approach came after the publication of probabilistic risk analyses prepared on behalf of the applicant for the proposed facility [23], which claimed that the individual and societal risks were very small, but which were challenged as subject to large uncertainties [24].

The State of California, for some reason has chosen not to impose the same restrictions by law on LPG (liquified petroleum gas), which is considered in many circles to be at least as hazardous as LNG. The new Master

Port Plan for Long Beach and Los Angeles would address new LPG facilities but does not cover the existing facility.

4. Discussion

As noted in the introduction, there is a growing trend among many federal regulatory agencies to use quantitative assessment of risks as an important input into decision-making. The US Nuclear Regulatory Commission has published a safety policy which includes quantitative risk guidelines. The US Environmental Protection Agency has for years published estimated risks to the public and to workers from exposure to specific chemicals. The recommended public risk level not to be exceeded, except under special circumstances, usually was 10^{-6} additional risk of cancer due to lifetime exposure to a specific chemical at the proposed concentration limits.

An examination of how State of California agencies have dealt with several specific energy related situations involving risk shows that highly varied approaches are taken by the state as part of the decision-making. The approaches vary from primary reliance on standards and inspection for pipeline safety to the assumption of a "maximum credible" accident in the footprint approach for the Port of Los Angeles.

The Study Group concludes that the development of quantitative safety goals for risk management of energy systems in California does not seem to be a useful exercise for a variety of reasons, including the following:

- The current approaches to regulation of energy systems seem to meet the needs of protecting the public health and safety, for the most part. Furthermore, it is not clear how quantitative safety goals could be defined generally or specifically for such systems, and if they were, how they would be of much help
- One large obstacle to the generation of quantitative safety guidelines lies in the great difficulty in quantifying the health and safety risks of interest In most cases, it appears that large uncertainties will exist in estimates of risk.

Decision-making or risk management does not rest solely on a quantification of risk but generally includes a host of other economic, psychological, philosophical, political, sociological and legal factors [11, 25, 26]. These factors would certainly enter into any effort to establish quantitative safety goals or objectives for energy systems in California, and the overall process is very complex and generally would emphasize different attributes for each problem [27].

On the other hand, the Study Group believes that there does appear to be a role for the equivalent of an office of risk management in the State governmental structure [12]. Although an advanced state like California already does risk evaluation for various risk situations now (for example, in the control of contaminants in food and drinking water), and has made increased efforts to develop an approach to risk management, history tells us that even in California risk situations develop, such as chemical waste disposal sites that may be hazardous to nearby inhabitants now and distant inhabitants in the future. Similarly, in the case study on conservation measures, PUC acted to approve insulation measures which would reduce airflow exchange and hence aggravate indoor air pollution health problems. Furthermore, for many risk situations, one is able to say, after the fact, that it would have been cheaper and otherwise preferable to act in a preventative mode, rather than an emergency or mitigative mode.

It is noted that many states are much less advanced than California and a broad quantitative grasp of risk may not generally exist at the state level [12]. Hence, we are led to suggest that it might be valuable to have a central state office (or its equivalent via a coordinated group of offices) which would include the following services and responsibilities:

- Serve as a reference library and source of information of knowledge of societal risks
- Scrutinize the state for unevaluated situations posing a considerable potential for individual or societal risks
- Make preliminary estimates of risk (probability versus frequency) for unevaluated risk situations which appear to warrant some examination
- Notify appropriate state officials, offices or departments about potential new risk situations, if some threshold condition for such notification appears to have been met (this would require the establishment of threshold levels for action of different kinds)
- Provide risk evaluation service for other state governmental groups upon request
- Develop alternative risk management approaches for consideration by a state office or agency having decision-making responsibility.

It is relevant to emphasize the potential usefulness of establishing threshold levels of risk for different actions such as:

- an individual or societal risk level which warrants notifying the responsible state agency
- a risk level which warrants notification of the governor and the appropriate legislative committees
- a risk level which warrants notification of the public potentially affected
- a risk level which warrants early remedial action.

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Appendix: Five case studies

1. Gas pipeline safety -- The federal government and state agency perspectives

1.1 Introduction

There are several types of natural gas pipeline accidents that pose a risk to the public health and safety. Most accidents result from outside forces such as an excavator or an automobile breaking a pipeline or pipeline meter and causing it to leak. Such a leak can travel quickly into a building and cause an explosion to occur. Another major cause of accidents is pipeline leaks resulting from corrosion of a pipe's casing or materials. Such accidents have killed and injured people and pose a greater risk to the general public than to pipeline workers. The quantification of such risk might help determine how great a risk such accidents pose to the public health and safety. In this Appendix, both the perspectives of the federal government and of a major state agency dealing with pipelines are examined. The question is raised as to what attributes are taken into account in making decisions about pipelines.

1.2 Federal regulations on safety

As described in the federal manual "Guidelines For States Participating In The Gas Pipeline Safety Program", the Natural Gas Pipeline Safety Act of 1968, as amended by Title 1 of the Pipeline Act of 1979, provides for a partnership between the States and the Federal Government in regulating and enforcing gas pipeline safety standards. State participation in the gas pipeline safety program is based upon voluntary submission of a Certification pursuant to Section 5(a) of the Act or of an Agreement pursuant to Section 5(b) of the Act. Under a certification, a State agency assumes safety responsibility with respect to intrastate gas facilities over which it has jurisdiction under State law. Under an agreement, a State agency assumes surveillance and inspection responsibility for intrastate facilities, and reports probable violations to the Office of Operations and Enforcement (OOE) for enforcement actions. Section 3 of the Act provides that with respect to intrastate pipeline facilities, a State agency may issue additional or more stringent safety regulations as long as the regulations which the agency issues are compatible with Federal regulations.

One of the attributes taken into account by the Federal Government with regard to pipeline decision making is the level of inspection effort to be utilized by each State in order to conduct a satisfactory gas pipeline safety program. The OOE has calculated the minimum level of inspection effort recommended for each State by basing its calculation on several criteria such as miles of pipelines, age of pipelines, number of services, corrosive nature of the State's soil geographic area of the State, number, size, and quality of gas operators, and number of gas incidents and fatalities. OOE concluded that the level of inspection effort for each State would be based on the following three criteria: (1) number of metered gas services, (2) miles of distribution main and for states acting in 1976 as interstate agents, the miles of transmission lines; and (3) number of distribution operators. Statistical data related to these three criteria were compared to the performance of selected state agencies in deriving a correlation between the chosen criteria and an adequate inspection effort.

The inspection and enforcement guidelines emphasize the dependence of the "overall quality and effectiveness of the gas pipeline safety program" on the information obtained through inspections. Thus, the State agency is required to have a plan for conducting its inspection activity that fits certain requirements.

The Federal guidelines claim that a State agency should conduct an on-site investigation of each significant accident on gas pipeline facilities under its jurisdiction. An accident is considered significant when it involves personal injury requiring hospitalization, fatality, or property damage exceeding US$5,000.00. Additionally, an investigation should be made when the accident appears to have resulted from a violation of a Federal or State safety regulation.

Two organizations of the Federal government have Federal authority regarding gas pipeline accident investigations, OOE and NTSB. The OOE notifies a State agency of an accident which occurred on pipeline facilities under its jurisdiction. The NTSB (National Transportation Safety Board) also investigates pipeline accidents but its authority is limited to transportation accidents. The OOE has made an agreement with the NTSB which establishes procedures for the notification of pipeline failures, investigation and program coordination so that investigations and information gathering are conducted in an effective, efficient manner. In those accident investigations where both a state with a 5(a) Certification and NTSB participate, authority is concurrent.

The Model Underground Utility Damage Prevention Act is a model statute that attempts to assure that underground excavators and utility operators establish communications prior to start-up of excavation, and take appropriate action to prevent incidents of damage to buried pipelines and other utilities. The amended Act requires a State to be "encouraging and promoting programs designed to prevent damage to pipeline facilities as a consequence of demolition, excavation, tunneling, or construction activity". Section 192.707 of the Federal gas pipeline safety regulations requires that line markers be installed over each buried main and transmission line wherever necessary to identify the location of such lines to reduce the possibility of damage or interference. However, this section provides that line markers are not required in urban areas "where a program for preventing interference with underground pipelines is established by law".

1.3 Attributes of federal decision-making

Some of the important attributes of federal decision-making on pipelines were provided in their guidelines for states participating in The Gas Pipeline Safety Program. These attributes listed below are concerned with safety decisions rather than decisions in general about pipelines.

1. Level of inspection effort.
2. Number of metered gas services.
3. Miles of distribution main.
4. Number of distribution operators.
5. Preparation of comprehensive state plans for conducting inspection activity.
6. In selecting operators and determining their risk, the ratio of total pipe to coated pipe, the ratio of total pipe to cathodically protected pipe, leaks per mile, unaccounted for gas, number of accidents.
7. The correction of all non-compliance of utilities by state agencies.
8. Whether or not an accident is "significant".
9. Existence of line markers installed over each buried main and transmission line.
10. Number of person-days a gas pipeline inspector devotes to inspecting gas facilities to ensure they are in compliance with gas pipeline safety.

1.4 In the federal view, how safe is safe enough?

In the federal view, gas pipelines are considered safe enough if they meet federal safety standards and regulations. It is not clear whether quantitative safety goals have been utilized in determining what safety standards should be. Such safety goals have not been mentioned in the federal safety guidelines, and thus if utilized at all in making up the original standards, they are not passed on to state agencies as criteria for judging levels of risks.

If an accident should occur, it is only labeled significant if someone needs to be hospitalized as a result, or if 5,000 dollars worth of property is damaged. This precludes the possibility that a potentially significant accident may be taken care of before such injury or damage is allowed to occur. It also precludes the possibility that a person may experience delayed or misinterpreted reactions to the accident in the form of psychological trauma, or disease that fails to receive immediate attention at a hospital. The federal government, however, calls for those accidents in which safety standards may be violated to be investigated as well as those labeled "significant". This factor (assuming that federal safety standards are fairly strict) may broaden the category of accidents worthy of attention to at least some of those accidents in which no one was injured. Thus, noncompliance with federal safety standards is viewed as equivalent to insufficient safety which must be corrected. The question remains, however, indeed do regulations protect the public at an acceptably low risk from the dangers of gas pipeline accidents.

1.5 Perspective of a state agency on pipeline safety — PUC, San Francisco, the decision-making structure

The Public Utilities Commission (PUC) is a quasi-legislative judicial body which has been given broad powers for safety in California's constitution. There are five commissioners appointed to the PUC for six-year terms by the Governor. They are the decision-makers on rules and regulations on safety as well as other aspects of pipelines. The five commissioners have five advisors on safety. In addition, the entire PUC staff acts as advisors to the commissioners.

The Commission's General Orders follow the standards set by the Department of Transportation. These regulations are changed from year to year. A circular process takes place in that utilities make applications for changes in the regulations, but if an accident occurs, the question is raised as to whether the utility failed to meet these standards. The NTSB points out bad practices after investigating accidents and then makes recommendations to PUC. These recommendations, according to the engineer, are probably not quantified and are not always followed since the NTSB is an investigatory body without authority to enforce its recommendations.

The PUC's responsibilities are set out in the Public Utilities Code (Section 315 and other parts of the code) to investigate accidents and it gives the commission authority to set standards. PUC administers both the Federal Standards and those set by their commission. The engineer states that the commission's standards are as stringent or more stringent than the Federal standards. The Federal Government has responsibility for regulating pipelines other than the ones PUC regulates, such as municipal, and non-utility pipelines. These are not PUC's responsibility.

1.6 Attributes of PUC's decision-making on pipelines

The most important attributes in PUC's decision-making about pipelines appear to be the following: cost of facilities; amount of budget allotted for safety; results of Leak Surveys; age of pipeline, what the pipeline is made of; density of area through which the pipeline passes; relation of pipeline risk to risk from other forms of energy; the need to follow and enforce the commission's safety standards, whether safety standards of federal government are also met; the role of politics (especially for commissioners); whether piping is protected from corrosion, whether excavators are warned of whereabouts of pipelines, and category of an accident (from most to least important).

1.7 Use of quantitative safety goals and comparative risk assessment by PUC -- San Francisco

Quantitative safety goals are not used by PUC in determining whether gas pipelines are safe enough, although comparative risk assessment is used. PUC has quality standards that help determine whether a given practice concerning pipelines is good. Examples of good practice are the use of cathodic protection, and participation in notification systems for excavators. The standards followed by PUC are qualitative rather than quantitative. The assumption is that such requirements of high quality act as a control against unacceptable risks. These standards are determined by the Federal Department of Transportation, and by PUC's commissioners. The safety of pipelines is weighed against these standards rather than quantified. If they do not meet these standards, corrections are made so that they do. Thus, in PUC's perspective, gas pipelines are safe enough if they meet both the federal government and commission's standards on safety on a continuing basis.

2. Geysers Unit 20 -- A new geothermal power plant

2.1 Introduction

Geothermal power plants, while able to effectively harness the heat or steam from natural geysers and rocks in order to generate electricity, also pose risks to the public health and safety. The primary risk of concern is that caused by the various kinds of pollutants emitted from these power plants, such as: hydrogen sulfide, particulate matter, sulfur dioxide, sulfates, nitrogen dioxide, carbon monoxide, oxidants, lead, non-methane hydrocarbons, boron, ammonia, benzene, arsenic, asbestos, and radon. One such power plant, known as Geysers Unit 20, was proposed in 1982 by Pacific Gas & Electric (PG & E) for approval by the California Energy Commission. In this section, the risk situation posed by this power plant is described, as well as the major attributes considered by CEC in making decisions about the plant.

2.2 Description of Geysers Unit 20 project

The proposed project consists of the construction and operation of a geothermal steam power plant 110 MW (net) electric power, as an economic alternative to fossil fuels for generation of base-load electric power. Geysers

20 would be located in eastern Sonoma County, about 65 miles north of San Francisco. Steam to operate the plant would be provided by Union Oil Company, and would come from the adjacent steam field in Sonoma County. Development of the power plant will require creation of a seven-acre flat-pad area at an elevation of about 2,825 feet. PG & E's contractors will prepare this area by excavating approximately 510,000 cubic yards of soil and rock which will be disposed of both on and off site. The project will consist of 4 principal features: (1) a power cycle consisting of a turbine generator and condensate and circulating water systems, (2) a multiple-cell, mechanically induced cross-flow cooling tower; (3) a transmission switchyard; and (4) a hydrogen sulfide abatement system with primary treatment through a Stretford system. The project will require about 15 steam wells to provide the initially required volume of steam, with additional wells required during its 30-year life span to make up for the decline in steam from producing wells.

2.3 Public health hazards of Geysers 20

In CEC's Final Commission Decision report on Geysers Unit 20, it is stated that, "The testimony concludes that, since applicable air quality standards are based in part on the protection of public health, compliance with these standards will likewise protect public health". CEC finds that the Geysers Unit 20 will comply with all applicable air quality standards, thus assuring protection against deleterious effects of regulated pollutants. In addition, CEC finds that the evidence of record does not support a reasonable potential for deleterious public health impacts due to emissions of non-regulated pollutants. PG & E will, however, be required to conduct monitoring of these emissions. CEC found the only identifiable potential adverse impact to be in the vicinity of the "Beigel Cabin", a part-time residence approximately 0.6 miles from the plant site. As a Condition of Certification, PG & E is required to notify occupants of procedures available should they feel that air quality degradation has occurred. Also, CEC claims that implementation of an accident prevention program approved by CAL/OSHA should adequately protect worker health.

It is, however, not clear to the Commission that arsenic, a non-regulated pollutant, would be emitted at or below suggested safe levels. Since such emissions may rise above such levels, the staff views this risk as indicative of the need to monitor non-regulated pollutants in geothermal steam and ambient air. PG & E has agreed to perform this monitoring.

The Preliminary Staff Assessment of Geysers Unit 20 discusses in more detail the potential human health effects from exposure to emitted pollutants. The Staff claims that such effects are generally associated with higher levels of exposure than would result from Unit 20 emissions alone, and are more applicable when considering the possible cumulative impacts of geothermal pollutants from Unit 20 in combination with those from other power plants in the Geysers area.

2.4 Major attributes considered by CEC in making decisions about the Geyser Unit 20 project

The following attributes appear to enter into decision-making: conformity of project with applicable local, regional, state and federal standards, ordinances and laws; compliance of project with identified public health and safety standards, and applicable air and water standards; adequate protection of endangered species of wildlife and plant-life, reasonably safe and reliable operation of the facility; government land use restrictions sufficient to adequately control population density in area surrounding the facility; housing and road impacts of the project; project location; financial impacts of project; seismic hazard; adequate handling and storage of hazardous, toxic, and flammable materials; adequate fire safety; adequate worker safety; transmission line safety and nuisance; noise created by project; socioeconomic impacts of project; maintenance of water quality; stipulated air quality findings, power plant efficiency; monitoring of non-regulated air pollutants, water run-off from project; waste management; and, impact on Beigel Cabin and on schools.

2.5 Did CEC utilize quantitative safety goals in its decision-making about Geyser Unit 20?

There is no evidence that CEC utilized quantitative safety goals in making decisions about Geyser Unit 20. Safety determinations were based on compliance by PG & E with set standards such as air quality standards. If geothermal emissions of pollutants were expected to go above the set maximum standard allowed, then CEC considered the risk as possibly unacceptable, and called for monitoring of that pollutant. It did not equate, however, such high emissions with impact on the public health, since such impact is often unknown. As already stated, in CEC's view, air quality standards are based in part on the protection of the public health, hence conformity with standards will likewise protect public health. Thus, CEC does not seem to see any reason to calculate risk probabilities, since it has already determined that the Geyser 20 facility would be complying with safety standards, and thereby not present any significant risk. In addition, CEC apparently does not deem it necessary to quantify the cumulative risks to the public health and safety of geothermal emissions throughout the area.

2.6 Was comparative risk assessment used by CEC in making decisions about the Geyser Unit 20 project?

It is not clear whether or not comparative quantitative risk assessment was utilized in making decisions about the project. However, it appears not to have been.

3. The safety and insurance requirements of QFs as determined by utilities and PUC

3.1 Introduction

Electric utility companies and other electricity producers, while providing the public with a valuable resource and service, also pose risks to the safety of that public as well as their own workers. Some of these risks are created by the fact that utilities often buy their electricity from energy producers called "Qualifying Facilities" or QFs. QFs are small power production facilities which "qualify" under 18 CFR, Chapter 1, Part 292, Subpart B, of the FERC regulations implementing the Public Utilities Regulatory Policies Act (PURPA) of 1978. One major risk posed by QFs and utilities is that downed utility lines may continue to be energized by a QF's generator due to the failure of required protective devices. If a worker or a member of the public should touch such an energized line, he/she may be electrocuted. Another risk is that a falling tower or a blade thrown from a rotating generator shaft could cause injury or death. In order to minimize these risks standards regulating the quality of safety equipment have been set by the California Public Utilities Commission. In addition, special insurance requirements for QFs under 100 kW have been determined by the Commission after findings indicated that low-kilowatt QFs could not afford the high price of insurance premiums required and also make a profit from their sales of electricity to utility companies.

3.2 Background information

Initially, Decision No. 82-01-103 of January 21, 1982 (also known as OIR-2), established the prices, terms and conditions regulating utility purchases of power from private co-generators and small power producers (QFs). These standards were established by the California Public Utilities Commission staff. Federal regulations require the appropriate state regulatory agency to establish reasonable standards to ensure safety and reliability of interconnected operations. Thus, OIR-2 consists of such standards and includes staff recommendations to utilities that the requirement for liability insurance be waived when the QF is 20 kW or less, providing its generator delivers power to the utility grid through a dedicated transformer.

Although the utilities for the most part agreed with the safety standards set by the Commission, two out of three major utilities failed to comply with the insurance recommendations of the Commission and required low-power QFs to pay for expensive insurance premiums. They also required very high liability rates, far beyond what the actual risk (based on a good safety record) would normally require. This burden on small QFs led to their making many complaints to the Commission about the problem. The Commission then held a Compliance Hearing on standard offers and tariffs filed in response to orders in OIR-2.

3.3 What are the major safety standards set in OIR-2?

The Commission staff identified three functional standards that it considered essential for safe and reliable operation, with a list of corollary conditions. The standards are as follows:

1. sense and properly react to utility failures/malfunctions;
2. assist the utility in maintaining system integrity and reliability; and,
3. protect the safety of the public and utility personnel.

The corollary conditions are that the QF provide protection against adverse conditions which can cause electric service degradation, equipment damage, and harm to others.

3.4 Summary recommendations of compliance hearings

1. QFs, 20 kW and under, when connected through a dedicated transformer, should not be required to provide the utility proof of liability insurance coverage. This insurance waiver applied also to those QFs, 5 kW and under which are not required to connect through a dedicated transformer.

2. QFs, 100 kW and under, should not be required to name the utility, or its personnel, as additional insured. Edison and SDG & E should be directed to so correct their applicable insurance clauses in this QF size category.

3. The maximum liability insurance coverage the utility may require of the 100 kW and under QFs, wherever it is not waived, should be as follows:

QF size:	Liability insurance
6 to 8 kW*	$100,000
Over 8 kW to 15 kW*	$200,000
Over 15 kW to 25 kW*	$300,000
Over 25 kW to 100 kW	$500,000

The type of liability insurance the small QF (25 kW and under) may provide to satisfy the utility needs includes liability under the normal homeowners, rental dwelling or renter's policies.

4. Utilities should be authorized to reflect under expenses, in general rate cases, reasonable additional costs of insurance and damage claims resulting from Commission limitations on insurance requirements the utilities otherwise may impose on QFs

5. The utility should not require a QF, of any size, to provide at QF expense, insurance coverage for any negligent act of the utility or its employees.

6. A small QF, 25 kW and under, which meets the utilities interconnection requirements yet is unable to obtain liability insurance, and for which the insurance requirement is not waived by an exemption, should have the following option: the utility should assume the additional liability risk

*Liability insurance not required for QFs 20 kW and under, connecting through a dedicated transformer, also 5 kW or under.

presented to it by interconnection with such a QF. This additional liability should be limited to claims that arise from the utility—QF interrelationship and not claims which do not involve the utility. On assuming this risk, the utility should be authorized to make a nominal charge of the QF of no more than $25.00 per annum.

7. Utilities should accept QF certificates of self-insurance from those QFs who provide and maintain a sufficient financial basis for self-insurance.

8. All of the above insurance matters, including waivers, should be on the basis that the QF is required to meet the utility interconnection safety standards authorized by this Commission.

9. The levels of insurance authorized and the utilities' loss experience, if any, should be reviewed again one year from issuance of a decision in these compliance hearings, and further changes and adjustments be considered at that time.

3.5 Were quantitative safety goals utilized in making decisions about QFs and QF insurance?

There is no indication that quantitative safety goals were utilized by PUC in making decisions about QFs and QF insurance. No calculations are given for levels of risk posed by QF accidents or utility accidents, or for their probability of occurrence. Emphasis is instead placed on historical data, indicating that for the few years that QFs have been operating there have been no reports of injuries or death resulting from their operation. This very good safety record, coupled with the stringent regulations requiring high-quality safety equipment, is viewed by the Commission as evidence of adequate control of risk. Likewise, the Commission did not find it necessary to determine risk probabilities when it determined realistic levels of insurance requirements for QFs. Rather it recommended that the unrealistically high amounts required of QFs by utilities be reduced to be approximately 10%, and preferably no more than 5% of the QF's expected annual gross revenue. This decision was not based on a calculated risk but rather on both the good safety record of QFs in the past, and on their inability to pay high insurance premiums and still make a significant profit.

3.6 Were comparative risks evaluated in making decisions about QFs?

It appears that comparative risks were evaluated implicitly in making decisions about QF safety requirements and insurance requirements in that the size of the QF generator was a major criterion in determining both the levels of safety equipment to be required, and the amount (if any) of insurance coverage needed. Thus, the larger the QF's power, the more stringent and comprehensive the safety requirements and the larger the insurance requirements

3.7 In PUC's view, how safe is safe enough?

In PUC's view, interconnection of utilities with QFs is safe enough when the three major functional standards are abided by, and when the QF provides adequate protection against the listed adverse conditions known to cause electric service degradation, equipment damage and harm to the public and personnel. The major criterion required to meet these standards is provision of high-quality protective equipment such as manual disconnect switches, and relay-operated circuit breakers, etc. Requiring QFs of over 20 kW to pay for liability insurance is another way to control risk, by making it possible to compensate people for damages caused by an accident. This measure however does not decrease the probability of an accident occurring.

PUC determines how safe is safe enough, by the historical records of QF performance, and by its judgment of the use of certain safety equipment as effective in reducing risk. Since QFs have (for their few years of operation) not as yet caused any reported injuries to the public, or personnel, PUC views them as already being quite safe. Provision of additional safety equipment is seen as making QFs "safe enough".

4. The Risk Management Plan amendments of the Ports of Los Angeles and Long Beach

4.1 Introduction

There are many risks posed to the public health and safety by the storage and transportation of hazardous bulk liquids at ports. The problem of how to control these risks effectively and still allow important industries to carry out their work is a complex one.

When the Coastal Commission certified the Long Beach Port Master Plan and the Los Angeles Port Master Plan, it did not certify those areas of the ports where petroleum, petrochemicals and similar bulk liquids of a hazardous nature are stored or transported, pending completion and certification of a Port Risk Management Plan. The Commission provided funds for a study to develop this plan which was a three-phased effort by the Ports of Long Beach and Los Angeles and the L.A. Fire Department. Phase I was an inventory of hazardous cargoes in the Ports. Phase II involved an analysis of the risk to people and other port activities and facilities from these hazardous materials. Phase III combined the information from the first two phases into an implementation plan. The Board of Harbor Commissioners of both ports have submitted their respective Risk Management Plans to the State Coastal Commission for certification as amendments to their Port Master Plans. The Adoption of these amendments would result in the issuance of hazardous liquid bulk cargo facility permits by the respective port governing bodies rather than by the State Coastal Commissions.

4.2 Risk management through "hazard foot-printing"

The Risk Management Plan amendments propose to provide a means for managing, controlling, and directing both existing and proposed developments in order to minimize or eliminate risks to life and property in and around the ports. This is to be done mainly through physical separation of hazards and "vulnerable resources" (people and property) threatened by these hazards. Facility design factors, fire protection equipment, and other areas of mitigation are also included in the plan.

"Hazard foot-printing" is a method for identifying the potential extent of damage due to an accident involving hazardous materials. Each footprint consists of an outline drawn on a map showing the area around a facility within which unacceptable adverse impact would occur, should an accident take place at that facility. Land configuration, weather conditions, the type and amount of the substance, and the type of incident must all be taken into account. The boundary of the footprint is determined by calculating the distance at which the impacts from a "worst-case" event will be reduced to levels which are not likely to cause injury or property damage. In order to demonstrate the hazard exposure due to each facility, it may be necessary to draw several hazard footprints to show the full range of possible events.

Once the vulnerable resources have been identified and the hazard footprints for existing facilities have been established, it is possible to determine the overlap between the two, and steps can be taken to minimize or eliminate the risk. Modifications or expansions of existing facilities that expand the hazard footprint overlap of vulnerable resources will not be allowed. No new hazardous liquid bulk cargo development shall be permitted which would create a hazard footprint overlying existing, planned, or permitted vulnerable resources. No new vulnerable resource shall be permitted to be located within the hazard footprint areas of existing or approved facilities handling hazardous liquid bulk cargoes. The overlap between vulnerable resources and hazard footprints is determined by overlaying hazard footprints on vulnerable resource maps, and thereby clear indication of the type and degree of risk exposure.

4.3 Types of hazards involving liquid bulk material

4.3.1 Radiant heat

Thermal radiation or radiant heat generated by flames is the primary cause of damage resulting from a fire. The danger presented to any animate or inanimate object depends on the nature of the object as well as the intensity of the heat flux. The danger to people is the primary concern. Inanimate objects of greatest vulnerability are those made from structural metals. The border of the footprint showing hazard to personnel from radiant heat is drawn at the furthest distance from the place of potential fire where a heat flux of 1,600 British thermal units (Btu) per hour per square foot will occur. Exposed personnel within this distance will feel extreme pain within 15 to 30 seconds and will suffer second degree burns after 30 seconds.

4.3.2 Dangerous gases and other health hazards

A number of gas-producing liquids are handled at the port, such as styrene. A gas cloud from a release of these liquids, traveling at the speed of wind, can cause anything from irritation of the eyes and nose, to death, depending on the concentration of the vapor. In the case of styrene, fumes from the burning liquid can asphyxiate people. For each gas, a different hazard footprint applies. In some cases, the hazard footprint is drawn to indicate an extent representing the fatality threshold after half-hour exposure to the toxic fumes. Styrene or other liquids producing flammable gas clouds should be considered for their flammable characteristics rather than (or in addition to) toxicity as a vapor cloud. Therefore, the extent of their hazard footprints also should be calculated in terms of their lower flammability limits.

4.3.3 Blast over-pressure

Blast over-pressure is the term used to describe the blast waves generated by an explosion. Only about one pound per square inch (psi) of over-pressure will also shatter glass windows and cause damage to light structures. Five psi can rupture human eardrums and 20—40 psi will cause lung collapse. The boundary of a blast over-pressure hazard footprint for personnel should be drawn at the distance from the explosion where 5 psi would be felt. Although a person possibly could withstand greater pressure without suffering injuries, light structures and storage tanks could not.

4.3.4 Flying missiles or fragments

Explosions and the resulting air blast are generally accompanied by flying fragments or debris. These "missiles", sometimes traveling at very high speeds, can severely injure or kill people or cause damage to structures or tanks. Although there is no way to predict the path of these flying fragments, historical data indicates that the chance of being hit by a missile beyond 1,500 feet from an exploding facility is extremely remote. Therefore, the hazard footprint boundary is set at 1,500 feet.

4.4 Vulnerable resources of the ports

The vulnerable resources (people and property) of the ports threatened by hazards are:

1. Residential Populations: Residents living in the areas around the ports represent the largest number of people exposed to risks.
2. Recreational and Visitor Populations: This group includes users of the marina, fishing piers, restaurants and hotels, and tourists visiting the ports.
3. Working Populations: The working populations in the ports are exposed to the greatest amount of danger from hazardous bulk materials. However, safety training and emergency evacuation procedures can be instituted.

4. Critical Regional Activities/Facilities: A critical regional facility is one which is important to the local or regional economy, the national defense, or some major aspect of commerce. The U.S. Navy shipyard and the Vincent Thomas Bridge are two examples.
5. High Value Facilities: A high value facility is one which has a very high economic value, such as a container-storage area.

4.5 Requirements to do a risk analysis

The Implementation Guidelines state the following: "If the development may involve the storage or transfer in liquid bulk form of any hazardous material or if the development may place a vulnerable resource within an existing hazard footprint as described in the Risk Management Plan, then the report shall include a risk analysis as specified below".

The risk analysis, if required, shall include the following:

1. Hazard footprints with supporting calculations. A diagram(s) showing the maximum extent of hazard footprint areas attributable to the development, if any. Footprint calculation methodology shall be in accordance with the Port Risk Management Plan.
2. Vulnerability map. A map showing the nature and extent of vulnerable resources lying within the hazard footprint(s) generated by the development, with indication of the kind of hazard(s) involved and vulnerability levels considered.
3. Specific case hazard assessment, considering the specific casualty or accident possibilities and the kinds of damage or injury which could occur, and facility design features, procedures, and other risk mitigation measures by which the probability or severity of such damage or injury could be reduced.
4. Written comments by the City Fire Department, including a statement of whether the Department concurs, concurs with conditions, or does not concur with the granting of the development permit.
5. Written comments received from other public agencies regarding hazards or vulnerability of the development.
6. Terms and conditions required to ensure conformity of the development with the Port Master Plan or required by the Fire Department.

4.6 Summary of risk management measures existing prior to development of the risk management plan amendments and still in use

The existing risk management measures are generally complied with voluntarily by the port tenants and operators, but are enforced by various combinations of the U.S. Coast Guard, the Fire Department and the port's pilots and security forces.

The existing risk management measures may be logically divided into three areas which are called: (1) Vessel Traffic Management and Piloting; (2) Fire Department Requirements and (3) Spill Prevention Regulations.

4.7 What major attributes are considered in making decisions about liquid bulk containment at the two ports?

1. The characteristics of the specific cargo, particularly its stability and the external conditions which affect it.
2. The operational methods of handling and transferring.
3. The specifications, design, and geographic location relative to adjacent facilities, of man-made facilities constructed to handle, store, transfer, and transport such cargoes.
4. The natural characteristics and stability of the facility location such as seismic, topographic, hydrographic, meteorologic and hydraulic conditions.
5. The volumes of such cargoes handled or transferred in any given time period as the basis for evaluating and quantifying risk exposure.
6. The location of vulnerable resources.
7. The risk exposure measure.
8. Determining the level of risk mitigation equipment and design features as a function of the proximity of mobile fire protection resources.
9. Cost (i.e., bulk, the most economical way to handle hazardous commodities).
10. Distance of new hazardous bulk facilities from existing or planned concentrations of people or vulnerable facilities and vice versa.
11. Whether or not risk is premised on highly improbable events.
12. Whether conclusions about particular risks are highly speculative.
13. Whether the greater public interest is associated with the water-borne movement of the foreign and domestic commerce of the nation.
14. Long-term efficient land use planning considerations.
15. Ability of new technology, including equipment, materials, procedures, regulations and enforcement to render risk improbable.
16. The adequacy of fire protection measures and designed safety features.
17. Calculation level employed in hazard footprints for each type of risk.
18. The nature of the population at risk.
19. The value in dollars of high value facilities at risk.
20. The NFPA hazard rating of a hazardous material with respect to its flammability, reactivity or health hazard.
21. The initiating event causing an accident involving liquid bulk materials.
22. The quantity spilled or released during an accident.
23. The nature of the material spilled or released during an accident.
24. Public opinion about liquid bulk containment and about the risk management plan amendments.
25. Population density.

4.8 Are quantitative safety goals utilized in the risk management plans?

It appears that quantitative safety goals are not used or required in the risk management methods proposed by the two Risk Management Plan amendments. The plan views hazard foot-printing as sufficient means of determining what risks are posed to the public health and safety and to what degree. This attitude is shown in the following quote stated on page 7 of the Long Beach Risk Management Plan and page I-3 of the Los Angeles Risk Management Plan:

"The hazard footprints are overlaid on the vulnerable resource maps, providing clear indication of the type and degree of risk exposure. This technique of hazard foot-printing eliminates the need for arguments based on the probability of occurrence of casualties. The technique shows the risk exposure should an incident occur, the reduction of which is the focus of risk management".

The risk management policy of the two plans emphasize the "reduction of the consequences of a casualty by containment or control of the casualty or by reduction in the exposure of vulnerable resources" (page 8 LB plan). In the view of these two plans, quantification of risk probabilities is not necessary, since their major concern is the extent of the damage, not the chance of it occurring. However, in creating hazard footprint boundaries, an implicit quantification of risk probabilities occurs since such boundaries imply acceptance of a certain distance from an accident being sufficiently safe. The hazard foot-printing technique is supposed to base this distance on the "worst-case" accident

The only requirement that might potentially make use of quantitative safety goals is case hazard assessment. Although this requirement entails considering the special casualty or accident possibilities, and the way in which the probability or severity of such damage could be reduced, it does not call for a determination of what the probability of damage occurring actually is. Thus, case hazard assessment is conducted without the use of quantitative safety goals and still fulfills the requirements for risk analysis. It thus appears unlikely that hazard probabilities will be quantified in implementing the two Risk Management Plan amendments. The catastrophic results of an accident, regardless of its probability are to be controlled by these plans through separation of hazards from vulnerable resources.

4.9 In what cases are overriding considerations made so that exceptions to safety rules are made? How are these overriding considerations assessed?

"Overriding considerations" can permit for the overriding of all siting criteria in the two amendments. The amendments state that "No broad risk management policy can be rigidly enforced in every development without encountering circumstances where enforcement becomes unreasonable or contrary to pursuit of the overall policy of eliminating or minimizing hazard exposure of vulnerable resources". Examples given of such exceptions are: (1) when port development is proceeding in phases or steps resulting in temporary hazard footprint overlap; (2) when timing of availability of suitable relocation areas prevents elimination of hazard overlap, etc. The plan describes these obstacles as "long-term efficient land use planning and the economic considerations subsumed within". When such circumstances occur, the plan states that additional mitigation measures such as fire protection, design features, or equipment may be required.

Overriding considerations may also apply in those cases where certain risks are premised on highly improbable events and where development permits denial interest. This interest is that "associated with the water-borne movement of the foreign and domestic commerce of the nation" (LB plan p. 29). In such cases, the Board of Harbor Commissioners may grant a permit for a development which is in conflict with certain policies of this program, provided that it first adopts findings justifying why it believes the benefits of the proposed development override the calculated or assumed risk.

In order to support the application of overriding considerations for granting a permit, the Board of Harbor Commissioners must make a finding for each risk management policy or criterion which conflicts with the decision to grant a permit that long-term efficient land use planning considerations will lead to the eventual overall reduction or elimination of hazard exposure, including the development permitted in this case.

The use of "overriding considerations" is intended to be the exception for issuance of permits and not the rule. The findings of applicable "overriding consideration" must be thoroughly justified by explanation of the inapplicability of other alternatives, how long-term land use planning will eliminate the risk management policy conflict, and how additional mitigation measures will reduce the risk to minimum feasible level during the interim.

With regard to the amendments' regulation of existing hazardous liquid bulk facilities, less stringent rules seem to apply. Although modifications or expansions that expand the hazard footprint overlap of vulnerable resources are not allowed except where overriding considerations apply, existing footprint overlap is not eliminated by the amendments. No provisions are required or recommended by the plans towards elimination of this existing overlap. In fact the plans state that "Projects previously permitted by the California Coastal Commission and which do not necessitate any major amendment to the project will not be required to be reviewed under the Proposed Risk Management Plan". It thus appears that the two amendments are geared towards controlling future developments and hazards but not towards eliminating existing developments and hazards.

4.10 Is comparative risk assessment utilized in making decisions about liquid bulk containment?

It is not clear from the given material whether or not comparative risk assessment is utilized in making decisions about liquid bulk containment. It seems that some comparison is made between different liquids and gases in calculating hazard footprints, and that non-hazardous liquid bulk (with a lower rating than 2) is not subject to the policies of these amendments. So, in that sense comparative risk assessment does seem to be utilized.

4.11 How do these risk management plans determine how safe is safe enough?

From the perspective of the two ports authoring the Risk Management Plan amendments, the plans determine how safe is safe enough through the hazard foot-printing technique in which vulnerable resources are separated from hazardous developments. In addition, the relative safety of different liquids is graded on a scale to ensure that those materials that present much potential risk to the public health and safety are controlled by the port rules and regulations. However, this effort to ensure safety is limited in that the ports do not require existing hazardous bulk liquid containments to be relocated if they are too close to vulnerable resources. Thus, it appears that these ports see a need for increased safety, but not for absolute safety. Although it is impossible to obtain total safety from risks, the amendments fail to strive to obtain these goals since they already view such ambitions as "unreasonable" or "not in the publics interest".

It thus appears that what the plan purports in theory is strict control over the location of hazardous developments and vulnerable resources as a means of decreasing risks to the public and to valuable properties. Since the probability of such risks occurring is not quantified, the question is raised as to how the ports really know how accurate their assessments of risks are, and whether or not they are sufficiently controlled. In addition, by limiting regulations to the development of new liquid bulk projects, how can the port be sure that previous existing developments do not pose a great risk to the public health and safety? Thus, what in theory appears to be a strict standard for evaluating risk and guaranteeing safety, is actually lacking in comprehensive applicability and adequate consideration of risk probabilities.

5. Energy conservation measures and indoor air pollution — The risk to public health

5.1 Introduction

There are many reasons why installation of energy conservation features in people's homes could be beneficial to homeowners, the electric companies and society as a whole. Such features would result in reduced electric bills, fewer new electric plants to build, and reduced dependence on other countries for oil. Despite these positive effects, there are many risks posed to the public health and safety by the installment of energy conservation measures. Not only can fires result from ignition of insulation materials, indoor air pollution may greatly increase since ventilation of hazardous gases and radioactive indoor radon may be decreased. In this section, the conservation measures proposed by PUC, CEC and utilities such as PG & E are described, as well as some of the mentioned accompanying risks in an effort to determine what major attributes have been taken into consideration by decision-makers on this issue.

5.2 Background information on PUC's policies regarding residential weatherization programs and materials

The California Public Utilities Commission has approved weatherization financing programs for the gas and electric utilities subject to its jurisdiction, such as the Zero Interest Program (ZIP) for the Pacific Gas and Electric Company (PG & E) and the Weatherization Financing and Credits Program for the Southern California Gas Company. The Commission concluded that additional incentives are necessary to overcome the obstacles facing ratepayers which prevent them from participating in energy conservation programs. Thus, by authorizing PG & E to implement its zero-interest financing programming, the Commission is making it easier for homeowners to pay for ceiling insulation, weatherstripping, caulking, and other insulation measures. Such measures are supposed to be cost-effective, in that energy is saved, rates go down, and less energy needs to be produced or bought by utilities in the long run.

After PUC had authorized various residential weatherization programs, numerous requests were received by the Commission for qualifying new products and materials for these programs. As a result, the Commission adopted Resolution No. EC-20 which authorized certain new materials and procedures for insulating flat roofs and exposed beam ceilings. Several Commissioners then recommended that a method for qualifying new products and materials involving other responsible agencies be adopted; as a result the Weatherization Products and Materials Qualifying Committee was subsequently established.

5.3 Characterization of the hazard

In the article, "Indoor Air Pollution: A Public Health Perspective", John Spengler and Ken Sexton [21] describe a variety of risks from several kinds of indoor air pollutants and recommend that such risks be further investigated. They state: "Sidestream tobacco smoke, radon and radon decay products, asbestos fibers, fiber glass, formaldehyde, combustion by-products (such as polycyclic aromatic hydrocarbons, nitrogen dioxide, carbon monoxide, hydrogen cyanide, and sulfur dioxide), aeropathogens, and allergens are associated with a range of problems from mild irritations of nasal and mucous membranes to irreversible toxic and carcinogenic effects". In addition to describing all of these indoor air pollutants, they discussed the potential hazard to public health from synergism of pollutants (especially with cigarette smoke). In particular, they stressed the importance of limiting public exposure to asbestos. In what follows below, we concentrate on the hazard from radon.

5.3.1 Source

Radon-222 is part of the decay chain of uranium-238. It has a half-life of 3.8 days and decays by emitting alpha particles and gamma rays. Several of its decay products also emit alpha particles (polonium-218). Alpha particles are of particular importance, because they can do the most biological damage. The final stable product of the chain is lead-206.

Radon is a noble gas, thus possessing high mobility. Uranium-238 and its decay products (e.g., radium-226) occur naturally in soil, rocks and water. Therefore, radon can enter a dwelling in a variety of ways, as shown in Fig. 1 [22].

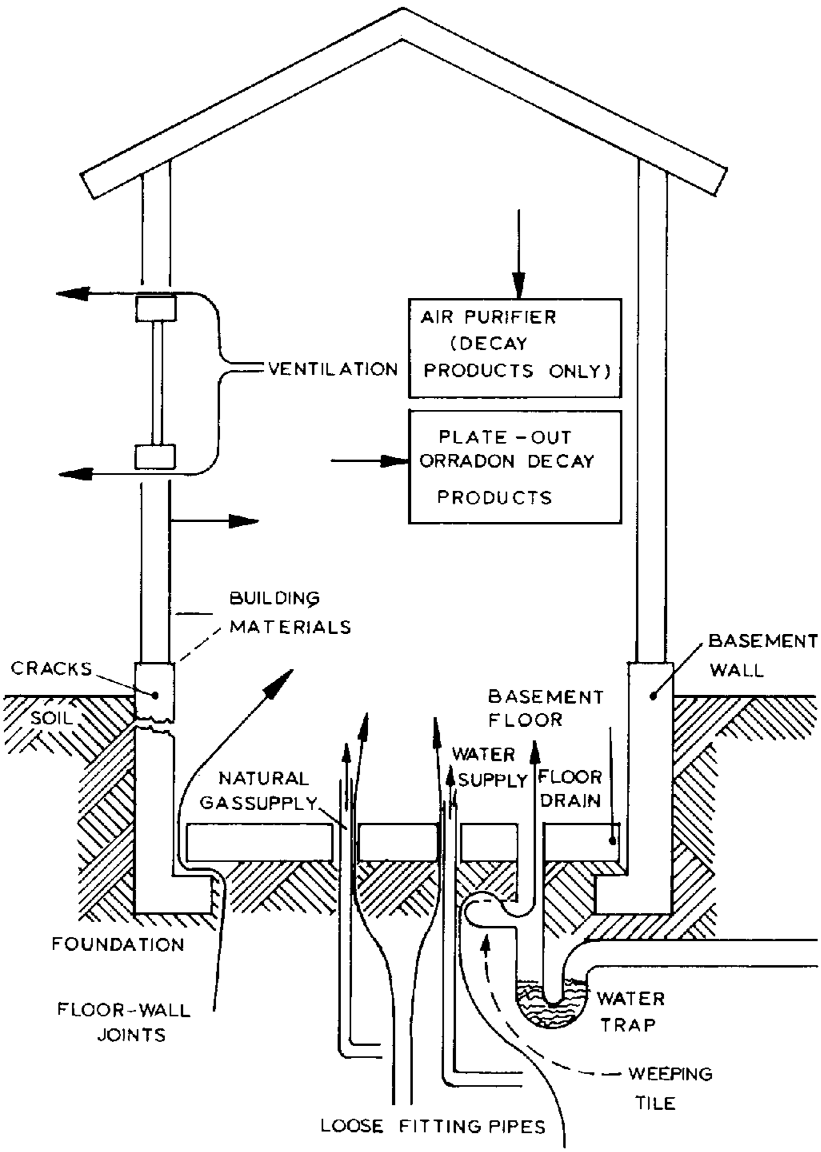

Fig. 1. Radon pathways in a typical dwelling [22].

5.3.2 Exposure process

The outdoor concentration of radon is very low; therefore, people are exposed to it and its decay products principally when they are indoors. The fraction of time that people spend indoors is in the range of 70—90% [22]; this fraction is almost 100% for the segments of the population who are particularly susceptible to health risks, like the old, the infirm and the very young [28].

When radon itself is inhaled, the damage is minimal, because it does not adhere to the lungs (most of it is exhaled); the decay products, however, can remain in the lungs for a long time, emitting alpha products that may lead to lung cancer. The most significant decay products in this respect are polonium-214 and -218 [20]. These daughters are typically attached on aerosols, when they are inhaled.

The concentration of radon in the air can be measured in pCi/l (picocuries per liter). Since most of the damage (to the lungs) is done by the daughters, a special unit for exposure has been devised, the Working Level Month (WLM)*, which is used in mining. The current occupational limit for uranium mines is 4 WLM per year [20].

The parameters that determine the level of exposure to radon and its daughters are the "source" term, i.e., building materials and geographical location, and the rate of exchange of indoor air for outdoor air.

Hurwitz [22] offers as a "typical" concentration for radon in U.S. homes the value of 0.8 pCi/l, which translates into about 0.12 WLM per year. A range of 0.01—4 pCi/l is more or less typical [20, 21]; this would translate into 0.0015—0.60 WLM/y (small variations can occur, if one makes different assumptions from those of Hurwitz regarding the indoor concentration of decay products and the number of "working months" per year). Spengler and Sexton [21] cite studies that have reported concentrations as high as 27 pCi/l (4.05 WLM/y) in Maryland and 81 pCi/l (12.15 WLM/y) in Sweden. They also state that in "energy efficient" houses levels exceeding 20 pCi/l (3 WLM/y) have been reported.

The unit of "air changes per hour" is used to measure the house volumes exchanged per hour. Its reciprocal is the air-exchange time and its value is typical in the range of 0.5—1.5 hours for older unsealed houses, while for energy-efficient houses it could be as high as 10 hours [22]. The indoor levels of radon and its daughters are, roughly, proportional to the air-exchange time.

5.3.3 Risk estimates

Hurwitz [22] estimates that the lifetime risk of cancer associated with normal exposure, i.e., 0.8 pCi/l or 0.12 WLM/y, is 0.1% to 0.4% (this corresponds to 1—5 cases per 10^4 WLM).

*"One WLM is defined as exposure for 1 working month of 170 h to a concentration of one working level (WL), where one WL is any combination of short-lived decay products of radon-222 per litre of air that will result in the emission of 1.3×10^5 MeV and α energy during complete decay" [29].

Nero [20] assumes an annual exposure of 0.2 WLM and estimates a range of 10 to 100 lung cancers per million per year, which translates to 0.5—5 cases per 10^4 WLM, a range that is similar to that of Hurwitz. Evans et al. [29] suggest an upper bound of 1 case per 10^4 WLM, which is, again, within the cited ranges. The same authors cite as the highest estimate reported the value of one case per 10^3 WLM.

For a U.S. population of about 230 million people the preceding estimates yield a range of 2,300 to 23,000 lung cancers per year.

5.4 The stakeholders

5.4.1 Intervenors

Several individuals have raised the issue of the need for action on the indoor air pollution problem and, in particular, on radon and its daughters. The principal arguments are two; first, the risks from indoor radon are comparable to other risks, which are currently regulated; and, second, the indoor radiological problem has not become an input into the decision to develop energy-efficient houses.

Hurwitz argues that consistency is lacking in society's handling radiation risks. He finds it "surprising" that the "fact that indoor radiological exposures can be comparable to the average exposure that would be received by the imputed victims of a hypothetical uncontained nuclear meltdown has not been emphasized" [22]. (The radiological exposure of 600 mrem/y for 15 years is cited as the American Physical Society's estimate resulting from an accident. Hurwitz estimates that some people are exposed to 1000 mrem/y.)

The impact of "energy conservation" on houses is a reduced air-exchange rate. Since, as stated earlier, the indoor levels of radon and its daughters are inversely proportional to the air changes per hour, the amount of reduction and the number of houses affected directly influence the estimated risks. Thus, Nero [20] estimates that a vigorous energy-conservation program that would reach practically every house and which would reduce the average infiltration rate by a factor of two, would result in doubling the number of cases cited earlier, i.e., it would yield 2,300—23,000 additional lung cancers per year.

Hurwitz [22] states that even routine energy-conservation measures like weather-stripping doors and windows and caulking cracks can reduce air infiltration by 20%, leading to exposures for some people of the order of 20 mrem/y, which exceeds the 5 mrem/y that is the limit on the boundary of a nuclear power plant, and the 1 mrem/y limit in the vicinity of a high-level waste repository. He further states that the risk is 4 to 5 times greater than the lifetime risk estimated by the U.S. Consumer Product Safety Commission for formaldehyde foam insulation that has been banned. Therefore, the issue of consistency persists.

Hurwitz [22] complains strongly about the lack of interest in the indoor radiological problem, as the following quotation indicates:

"the de facto national policy of sidestepping the indoor radiological issue is somewhat surprising in view of the fact that low-level radiation has caused such concern in other contexts. (After all, breathing radon decay products is, from the biological standpoint, similar to breathing plutonium.) . . . . The public has not been presented with a credible scapegoat to bear the opprobrium for the havoc that is imputed, and also to bear the direct cost of remedial actions [30]. As is evident from widespread public fear of radon from uranium mining, the characteristics that social psychologists claim are conducive to heightened public risk perception are certainly present, Slovic [31]. But, despite occasional mention of the indoor radiological problem in the media, a concerted campaign to inform the public has not been initiated."

5.4.2 Public

The general public is, of course, the principal stakeholder, since almost everyone is exposed to this hazard. General knowledge of the concerns, however, is lacking, nor have organized groups made an issue of indoor radiation. The Federal agencies that are stakeholders in this issue are discussed below.

5.4.3 Environmental Protection Agency

The EPA is the lead Federal agency for air pollution and for radiation policy. The responsibilities that are derived from the Clean Air Act are, however, restricted to the outside air.

A report to the Congress by the General Accounting Office [32] discusses the roles of several Federal agencies regarding indoor air pollution. The report states (and the EPA confirmed) that the EPA has estimated an additional 10,000 to 20,000 deaths per year due to lung cancer, if a vigorous energy-conservation program were adopted.

GAO has recommended (and the EPA has not objected) that "Congress aimed the Clear Air Act to provide EPA with the authority and responsibility for the quality of air in the non-workplace".

5.4.4 Department of Energy

The Department of Energy promotes energy conservation programs. It has disputed the EPA estimates of additional lung cancers by arguing that not every home will have to significantly reduce the air-exchange rate.

Nero's research [20] was supported by DOE. It is suggested that the Department's Residential Conservation Service (RCS) program could require a reduction of infiltration rates to about 0.50 air changes per hour and that such a measure would only create high exposure to radon and its daughters in a small number of houses determined mainly by geographical location. In these houses, additional measures could be taken to control radon entry, to clean the air, or to install mechanical ventilation systems that could incorporate a heat exchanger that would recuperate most of the heat normally carried by the ventilating air stream.

Nero also argues that there are several outcomes of the conservation measures and that increased indoor air pollution is only one. Reduced demand for electricity and the consequent reduced demand for power-generating facilities (on the order of several gigawatts) should also be included. He concludes that "it is simply not now known whether, on the average, infiltration reduction and associated changes in the energy system will have deleterious or beneficial effects on health" [20].

5.5 Description of final environmental impact report of June 1981 by CEC

The Warren—Alquist Act of 1974 requires the California Energy Commission (CEC) to adopt and periodically update energy conservation standards for new residential buildings. CEC staff has determined that additional and more extensive conservation measures will save much more money in energy bills than they cost. The staff thus released proposed new standards for energy conservation in new residential buildings which were then subjected to public review at hearings held by the Commission Building Standards Committee. The Staff Proposed Standards generated significant interest, comment and criticism, much of which was useful in further development of proposed standards.

A Draft Environmental Impact Report (EIR) on these Staff Proposed Standards was publicly distributed on March 13, 1981 for public review and comment, and a public hearing on the Draft EIR was held at the Energy Commission on April 15, 1981. The Energy Commission then assigned to the Residential Building Standards Project proposed revisions to the Staff Proposed Standards, referred to as the "Committee Proposed Standards". Although the Committee Proposed Standards would result in less energy savings than the Staff Proposal, they are considered to be more cost effective and would provide greater flexibility in design and construction of new homes. In addition, when compared to the Staff Proposed Standards, they would reduce the potential for adverse environmental impacts, according to the Final EIR. The Energy Commission staff has also recently proposed several amendments to the Committee Proposed Standards. These "new" Staff Proposed Amendments, are generally more stringent than the Committee Proposal, but less stringent than the "original" Staff Proposal.

The Final EIR incorporates by reference the Draft EIR on the original Staff Proposed Standards. It consists of (1) a summary of the potential impacts identified in each technical area of the Draft EIR; (2) a comparative analysis, by technical area, of potential impacts resulting from the original Staff Proposed Standards; and (3) response to comments received at the Draft EIR Public Hearing. The Energy Commission used this EIR, in conjunction with other material to determine whether, and under what conditions, proposed standards should be adopted.

The new Staff Amendments (as well as the original Staff and Committee Proposed Standards) require all new residences to have a list of mandatory features and devices, such as minimum ceiling and wall insulation, caulking, weatherstripping, lighting efficiencies, duct insulation, setback thermostat, hot water pipe insulation, and vapor barriers.

5.6 Public health summary of draft EIR

The draft EIR indicated that at least some California residences have potentially serious indoor air pollution problems. The Public Health Summary of the Draft EIR claims that by requiring air infiltration controls which reduce indoor air pollutant dilution and removal, the original Staff Proposed Standards would increase indoor air pollutant levels relative to those in homes without such air infiltration controls. CEC Conservation Division Staff estimated air exchange rates resulting from house design requirements for pre-1975, current Title 24, and the original Staff Proposed Standards to be 1.5, 1.3, and 0.6 air changes per hour, respectively. Based on these figures, the Staff Proposed Standards would reduce air exchange rates by at least 50 per cent over current Title 24 homes and 60 per cent over pre-1975 homes. When other variables such as pollutant source strengths and extinction rates remain constant, this reduction would lead to a corresponding increase in the level of indoor air pollutants. These pollutants include radon-222 and its daughter products, total suspended particulates, formaldehyde, NO_x, SO_x, carbon monoxide, various organic pollutants and trace elements. Chronic low-level exposure to any or all of these pollutants presents potential health hazards. CEC staff thus recommended that the standards avoid major reductions in estimated air-exchange rates and further recommended a number of alternative mitigation measures. CEC staff specifically recommended that electrical outlet gaskets and soleplate caulking be eliminated from the original Staff Proposed Standards until further research on this issue has been conducted. CEC staff also recommended that automatic mechanical venting of cooking areas be used as well as air-to-air heat exchangers.

The Committee Proposed Standards include several changes which partially mitigate potential adverse health impacts, while adding another potential source of indoor air pollution. These standards delete requirements for electrical outlet gaskets while retaining requirements for soleplate/building envelope caulking, thereby reducing air-exchange rates less than do the original Staff Proposed Standards. By retaining the requirement for soleplate/envelope caulking, the Committee Proposed Standards roughly produce a 30 per cent reduction in assumed air-exchange rates of new residences. Staff believes that this requirement should not reduce air-exchange rates significantly below currently experienced "average" rates in North American or California residences. Thus, the Committee and new Staff Proposed Standards appear to reduce but not to eliminate the potential for adverse impact to public health brought on by energy conservation measures as compared with the adverse impact that would be experienced if the original Staff Proposed Standards had been implemented.

5.7 Draft environmental impact report of April 1983 — Proposed non-residential building standards

In addition to residential buildings, the Warren—Alquist Act of 1974 requires the California Energy Commission (CEC) to adopt and periodically update cost-effective energy conservation standards for new non-residential buildings. The Draft Environmental Impact Report of April 1983 will be used by the Commissioners of CEC to determine whether, and under what conditions, the proposed standards should be adopted.

The health section of the study claims that the proposed standards' requirements for ventilation systems would affect human exposure to indoor air pollutants. Current CEC standards may not provide adequate ventilation where indoor pollutant sources are significant or outdoor air quality is especially poor. This is because current standards consider only ventilation rate requirements established previously and overlook recirculation and outdoor air quality prerequisites for the ventilation rate requirements.

In the Indoor Air Quality section of the study, the fact that the proposed standards do not include any requirements for the use of recirculating air, while current standards include such requirements is mentioned. It states: "ASHRAE 62-73 (section 5) allows the use of recirculated air to replace 67 per cent of the required outdoor air if particulate filters are included, and to replace 85 per cent of the outdoor air if high efficiency odor and gas removal equipment is employed. Treatment of recirculated air is especially important for office buildings where respirable particulate and gaseous contaminants from tobacco smoke can build up, presenting a clear health risk to all building occupants". They therefore claim that the proposed standards could result in a new indoor air quality impact by allowing the use of recirculated air without treatment.

5.8 What were the major attributes considered in decision-making by PUC about conservation measures?

The following attributes appear to have been used by PUC: cost-effectiveness of materials used in energy-conservation measures; safety of materials used in energy conservation measures; price of materials used in energy; chemical composition and off gasing of materials used in energy; the need for incentives to overcome obstacles facing rate-payers; amount of energy saved by conservation measures or materials; the length of the warranty of a proposed energy conservation material; the area in which the conservation program is to be implemented; and, the income level of home owners.

5.9 What were the major attributes considered in decision-making by CEC about conservation measures?

The following attributes appear to have entered decision-making about residential conservation measures by CEC: amount of money saved by extending conservation measures; cost-effectiveness of conservation matters; the flexibility in design and construction of new homes; the potential for adverse environmental effects; the relative stringency of proposed standards; the existence of indoor air pollution problems in some California residences; the estimated air-exchange rates in California homes; the pollutant source strengths of indoor air pollutants; the level of exposure to any or all possible pollutants; the impact of conservation measures on air-exchange rates, and on the likelihood of adverse effects; mitigation measures to reduce adverse effects of conservation measures; and risks to the public health.

5.10 Did PUC utilize quantitative safety goals in making decisions about conservation measures?

There is no evidence that PUC utilized quantitative safety goals in its decision-making about conservation measures. PUC claims "a high degree of standardization of construction details is desirable to assure safe, reliable and economical construction". The safety of conservation measures is determined by whether or not materials used meet the safety standards set by the Commission. Not only are the risks from conservation measures not quantified by PUC, they are not even fully examined. The lack of any mention by PUC of the risk to the public health of radioactive exposure to radon from increased indoor air pollution brought about by conservation measures is an example of this incomplete assessment of risk.

It does not appear that CEC utilized quantitative safety goals in their decision-making about conservation measures. This may be because of the lack of sufficient research data to make determinations about the probability of certain health impacts from indoor air pollutants. Although CEC views higher air-exchange rates as reducing the probability of health impacts as well as the extent of damage done from radon and other pollutants, it did not determine quantitatively what the risk probability actually is, and did not state what quantitative increase in risk might result from the proposed new conservation standards.

5.11 Did either PUC or CEC utilize comparative risk assessment in making decisions?

Both PUC and CEC claim to take the risks of not conserving energy and building more electric plants into account when assessing the overall risks to the public health and safety from energy conservation measures. Whether actual comparative risk assessment takes place is not clear. CEC pays much more attention to the wide scope of potential risks than does PUC, and thus would be much more likely to compare the various risks with one another. It, however, is not clear from the Final Environmental Impact Report of 1981 whether such comparative assessment has been done or not. More emphasis is placed on comparing air-exchange rates, and on mitigation measures than comparing the risks posed by different pollutants.

5.12 To PUC, how safe is safe enough?

To PUC, it seems that energy-conservation measures are safe enough if they meet the standards set by the Commission and the Weatherization Products and Materials Qualifying Committee. Materials must be non-flammable and non-toxic. No determination is needed in PUC's view of the probability of risk from various pollutants as long as the materials used are judged to be adequately safe according to set safety standards. Thus, risks from other sources in homes that may be aggravated by insulation measures are overlooked by PUC in their assessment of how safe is safe enough.

5.13 To CEC, how safe is safe enough?

CEC takes a broader look, and perhaps a more conservative stance in assessing how safe is safe enough than does PUC. It appears that CEC is dissatisfied with the safety of its own standards and sees a need for further improvement of mitigation measures to reduce risks if conservation measures are to be considered adequately safe. Thus, although CEC has set safety standards for conservation measures, it is more skeptical than PUC of the efficacy of these standards in substantially reducing risk. CEC believes that further research needs to be done on indoor air pollution so that more substantiated measures and standards can be developed. Thus, although CEC fails to utilize quantitative safety goals, they see a need for better understanding of the risks posed to the public health and safety by indoor air pollution and energy conservation measures.