

Risk-Informed Decision-Making

Initial Training

Federal Energy Regulatory Commission
Office of Energy Projects
Division of Dam Safety and Inspections



Welcome



Definition of Key Terms



Risk

Measure of the probability and severity of an adverse effect to life, health, property, or the environment. In the general case, risk is estimated by the combined impact of all triplets of scenario, probability of occurrence and the associated consequence. In the special case, average risk is estimated by the mathematical expectation of the consequences of an adverse event occurring (that is, the product of the probability of occurrence and the consequence, combined over all scenarios).



Risk

“The product of the likelihood of an adverse event and the consequences of that event.” *U.S. Bureau of Reclamation, Guidelines for Achieving Public Protection in Dam Safety Decisionmaking, 2003*

“Measure of the probability and severity of undesirable consequences.” *U.S. Army Corps of Engineers, Draft ER, 2009*

“Risk is a function of three terms: v_{LL} (frequency of life loss), LL (actual number of lives lost), and p (probability that provides a measure of the uncertainty in the analysis)” *Martin McCann, Stanford University*



Risk Analysis

The use of available information to estimate the risk to individuals or populations, property or the environment, from hazards.

Risk analyses generally contain the following steps:

- scope definition,
- hazard identification, and
- risk estimation.



Risk Assessment

The process of making a decision recommendation on whether existing risks are tolerable and present risk control measures are adequate, and if not, whether alternative risk control measures are justified or will be implemented.

Risk assessment incorporates the risk analysis and risk evaluation phases.



Risk Assessment

Risk assessment is a decision-making process, often sub-optimal between competing interests, that results in a statement that the risks are, or are not, being adequately controlled.

Risk assessment involves the analysis, evaluation and decision about the management of risk and all parties must recognize that the adverse consequences might materialize and owners will be required to deal effectively with consequences of the failure event



Risk-Informed Decision-Making

Decision-making, which has as an input the results of a risk assessment.

Risk information will play a key role in decisions related to dam safety but will not be the only information to influence the final decisions.

RIDM involves a balancing of social and other benefits and the residual risks.



Probability

A measure of the degree of confidence in a prediction, as dictated by the evidence, concerning the nature of an uncertain quantity or the occurrence of an uncertain future event.

It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

This measure has a value between zero (impossibility) and 1.0 (certainty).



Probability

There are two main interpretations:

- Statistical - frequency or fraction. The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an “objective” probability because it exists in the real world and is in principle measurable by doing the experiment.
- Subjective probability - Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias.



Uncertainty

Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. The level of uncertainty governs the confidence in predictions, inferences, or conclusions.



Unacceptable Risk
Tolerable Risk
Broadly Acceptable Risk



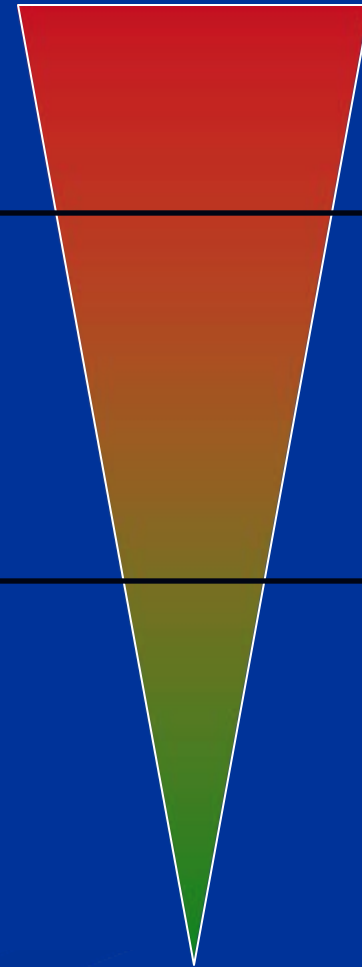
Risk Triangle

↑
Increasing individual risks and societal concerns

Unacceptable Risk

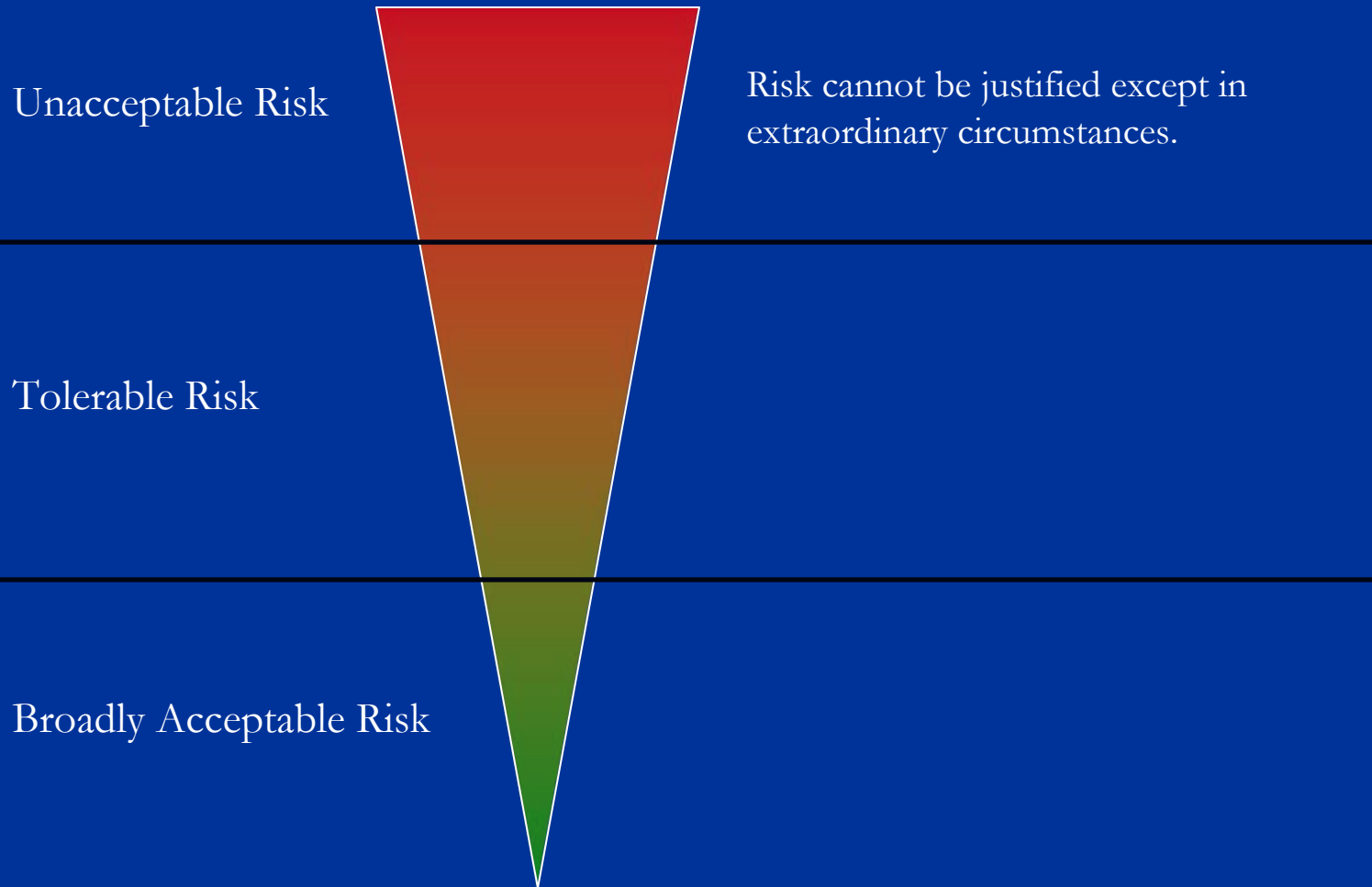
Tolerable Risk

Broadly Acceptable Risk

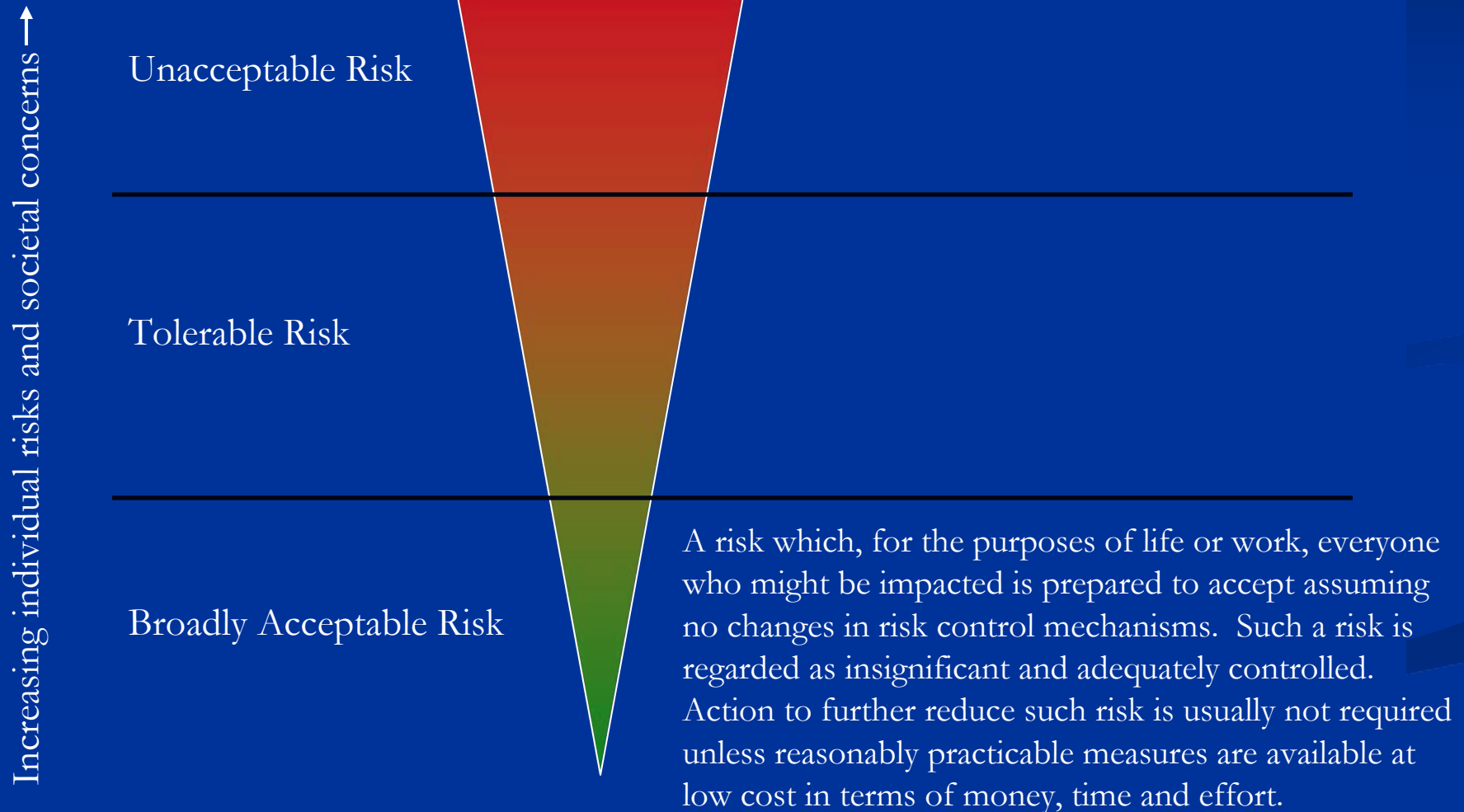


Unacceptable Risk

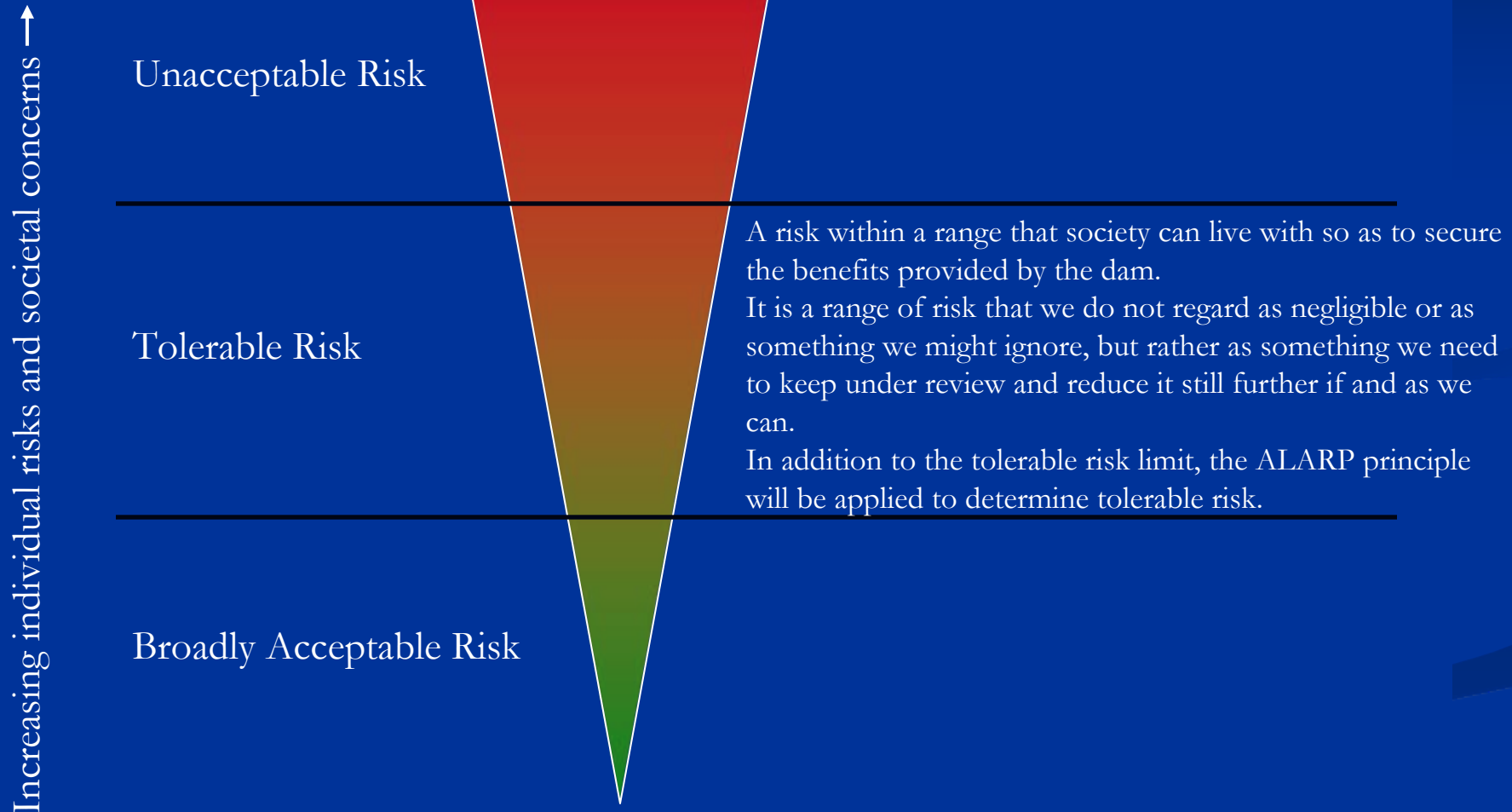
Increasing individual risks and societal concerns →



Acceptable Risk



Tolerable Risk

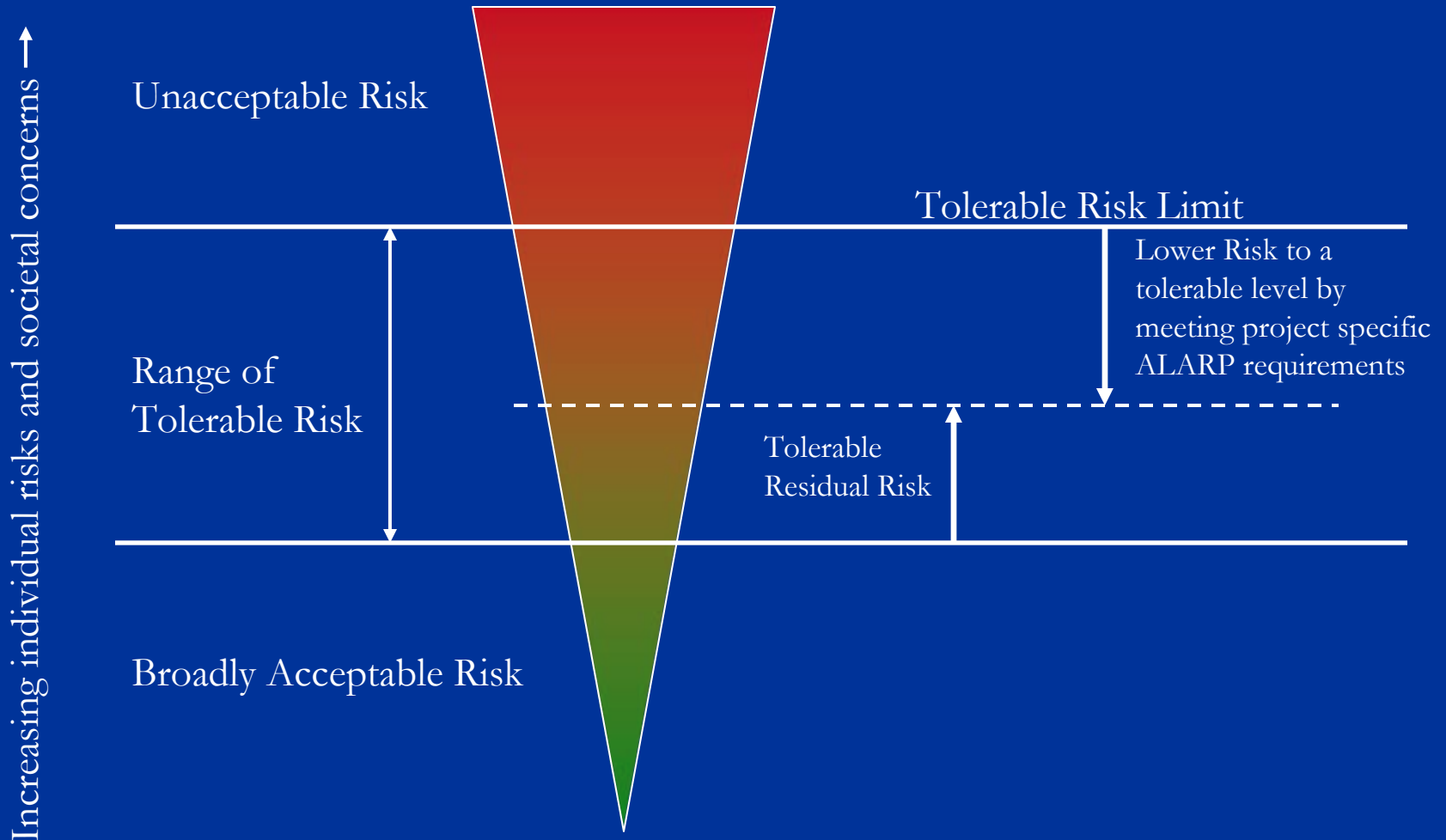


ALARP

That principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate (depending on the level of risk) to the improvement gained.



Tolerable Risk



What does FERC mean by RIDM?



Risk-Informed Decision-Making

- ▶ Decision-making, which has as an input the results of a risk assessment.
- ▶ Risk information will play a key role in decisions related to dam safety but will not be the only information to influence the final decisions.
- ▶ RIDM involves a balancing of social and other benefits and the residual risks.



Extension of PFMA process

- ▶ PFMA detail how a dam might fail.
- ▶ PFMA do not directly consider the scope of potential consequences.
- ▶ PFMA do not estimate the likelihood of an adverse event.
- ▶ RIDM will consider these items.



Risk-Informed vs. Risk-Based

- ▶ Risk-Informed implies using risk assessments as an input to decision-making.
- ▶ Risk-Based implies that risk is the basis for decision-making.



Role of Traditional Analyses

Traditional analyses will be required as inputs to the risk analysis process and to help assess the reasonableness of risk-informed decisions





What RIDM is Not

- 1) A way for owners to get out of doing work that needs to be done.
- 2) A way for FERC to make owners do work that doesn't need to be done



What RIDM Is

A way to make sure we do the right things



**Why is the FERC moving
towards a RIDM approach?**



Better Dam Safety

- ▶ Builds on PFMA process
- ▶ We (owners, consultants, FERC) will know more about our dams
- ▶ Considers the full range of consequences
- ▶ Better utilization of resources
- ▶ Standards based approaches only look at a few things – not necessarily the things that cause dams to fail.



Federal Guidelines for Dam Safety

“Risk-based analytical techniques and methodologies are a relatively recent addition to the tools available for assessing dam safety.

With further refinement and improvement, risk-based analyses will probably gain wider acceptance in the engineering profession and realize potential as a major aid to decision-making in the interest of public safety.

However, even when fully developed, risk analyses cannot be used as a substitute for sound professional judgment of engineers, contractors, or review boards.”



Federal Guidelines for Dam Safety

“Meanwhile, the agencies should evaluate the potential consequences of failure of the dams under their jurisdiction.”

“Although the value of potential property losses can be estimated, it is recognized that potential loss of lives can only be quantified, but not evaluated.”



Federal Guidelines for Dam Safety

“On new dams, potential losses can be used in study of project alternatives and in assessment of additional safety incorporated into the dam facilities.”

“On existing dams, a risk-based analysis should be considered in establishing priorities for examining and rehabilitating the dams, or for improving their safety.”



Federal Guidelines for Dam Safety

“The selection of the design flood should be based on an evaluation of the relative risks and consequences of flooding, under both present and future conditions. Higher risks may have to be accepted for some existing structures because of irreconcilable conditions.”



RIDM, Who's Using It?

- ▶ USBR, USACE, NSW, UK-HSE, BC Hydro, EDF, ANCOLD

- ▶ EPA, NRC, FDA, DOT, FAA, Many more



Why is the
FERC
moving
towards a
RIDM
approach?



FEDERAL ENERGY REGULATORY COMMISSION

The Strategic Plan



FY 2009-2014

www.FERC.gov



FERC Strategic Plan

In FY 2009, the Commission explored how risk assessment methodologies could benefit its dam safety program. The Commission determined that risk assessment could have the following positive impacts on its program:



- Better understand and quantify potential failure modes;
- Identify previously unidentified failure modes with high risk;
- Understand the consequences of potential failure modes on life, health and property;
- Understand the uncertainty and variability in traditional analyses;



FERC Strategic Plan

- Compare the safety of different dams using a common basis, risk;
- Compare the relative contribution to risk of all failure modes at a given dam; and
- Understand the risk associated with a single dam or the Commission's entire inventory of dams;
- Evaluate risk reduction alternatives and effectively reduce the risk that Commission-jurisdictional dams pose to the public in quantifiable and defensible terms.



FERC Strategic Plan

- ▶ In the event of a dam failure, there are both economic (property damage, environmental impacts and costs associated with loss of use of the resource) and loss of life consequences.
- ▶ Risk-informed decision making will enable the Commission to make better dam safety decisions that will, in turn, better protect life, health and property.
- ▶ Risk-informed decision making will be an added tool with which to assess dam safety.



Benefits to Owners and FERC

- ▶ It will not replace the other, more traditional, methods such as Commission inspections or independent engineering consultant inspections of dams.
- ▶ Provides a process to better understand and quantify potential failure modes;
- ▶ Identifies previously unidentified failure modes with high risk, in particular, non-traditional failure modes;



- ▶ Builds on the work completed in Potential Failure Mode Analyses (PFMAs) by considering the likelihood of failure and the consequences, including life, health and property, if a failure were to occur;
- ▶ Provides a means to compare the safety of different dams using a common basis - risk;
- ▶ Provides a means to understand the uncertainty and variability in traditional analyses;



Benefits to Owners and FERC

- ▶ Provides a means to compare the relative contribution of all failure modes to the overall risk at a given dam;
- ▶ Provides a means to understand the risk associated with a single dam or an entire inventory of dams;
- ▶ Provides a means to evaluate risk reduction alternatives and effectively reduce the risk regulated dams pose to the public in quantifiable and defensible terms;



Benefits to Owners and FERC

- ▶ Provides a means to identify critical systems and components
- ▶ Provides a means to focus surveillance and monitoring programs;
- ▶ Provides a means to improve Emergency Action Plans
- ▶ Focuses resources on those structures that pose the greatest risk. (FERC Strategic Plan)
- ▶ Risk provides a way to justify expenditures on dam safety. Risk is the common language in board rooms.



OBJECTIVE 2.2

SAFETY

Minimize risk to the public.

1. STRATEGY | Incorporate risk-informed decision making (RIDM) into the dam safety program

Long Term Performance Goal

- By FY 2014, risk-informed decision making will be incorporated into the FERC dam safety program.

ANNUAL PERFORMANCE TARGETS

FY 2010: Develop action plan

FY 2011: Portfolio Risk Assessment of FERC dam inventory

FY 2012: Determine RIDM is consistent with regulatory process

FY 2013: Finalize policy and technical guidelines

FY 2014: Fully incorporate RIDM into the dam safety program

Benefits to Owners



Report of the Independent Review Panel San Bruno Explosion



**Prepared For
California Public Utilities Commission**

**Revised Copy
June 24, 2011**







“The capability of a piece of pipe with a manufacturing defect to operate for 50 years in a stable manner is a tribute to the margin of safety built into the system. But the margin remains only if there is no uncertainty about the condition of the infrastructure. If the operator does not know about changes in the condition of the pipeline, then assuming the margin of safety is still adequate is an exercise in hoping to be lucky. To fail to inspect during major adjacent earth disturbance and then to fail to analyze the effect of that earth disturbance after-the-fact are examples of the operator pushing its luck.”



“There is no evidence top management has taken the steps necessary to be well-informed about the key aspects of decisions selected to manage major risks that concern PG&E.”



“The experience and knowledge base has been noticeably reduced over the last decade, partly due to retirements.

Compounding this loss of knowledge of operations knowledge is the presence of telecommunications, legal, and finance executives in top leadership positions. There is an under representation of engineers and professionals with significant operating experience in the natural gas utility industry in leadership roles.”



“Quality (risk) analysis could both facilitate two-way communication between top management and individuals with substantial knowledge about each of the relevant aspects of utility operations and provide a clear understanding of all the information available to make a key risk management decision.”



“Management could then ensure a full range of alternatives were considered in the decision and examine how each measured up in terms of each of PG&E's relevant objectives. They could examine what assumptions and judgments were used in integrating the available information to indicate the pros and cons of the alternatives. A quality analysis would highlight any significant missing information and provide a basis to examine whether it would be worth gathering if possible.”



The Independent Review Panel on the San Bruno explosion recommended the CPUC require:

“certification by senior management of the operator that parallels the certifications now required of corporate financial statements pursuant to Sarbanes-Oxley.”



The Sarbanes-Oxley Act, enacted after the financial collapse of ENRON, requires financial audits of companies to address the risks to the companies' financial well being.



Similarly the New York Stock Exchange rules require companies listed on the exchange to:

"discuss policies with respect to risk assessment and risk management."



"While it is the job of the CEO and senior management to assess and manage the company's exposure to risk, the audit committee must discuss guidelines and policies to govern the process by which this is handled. The audit committee should discuss the company's major financial risk exposures and the steps management has taken to monitor and control such exposures."



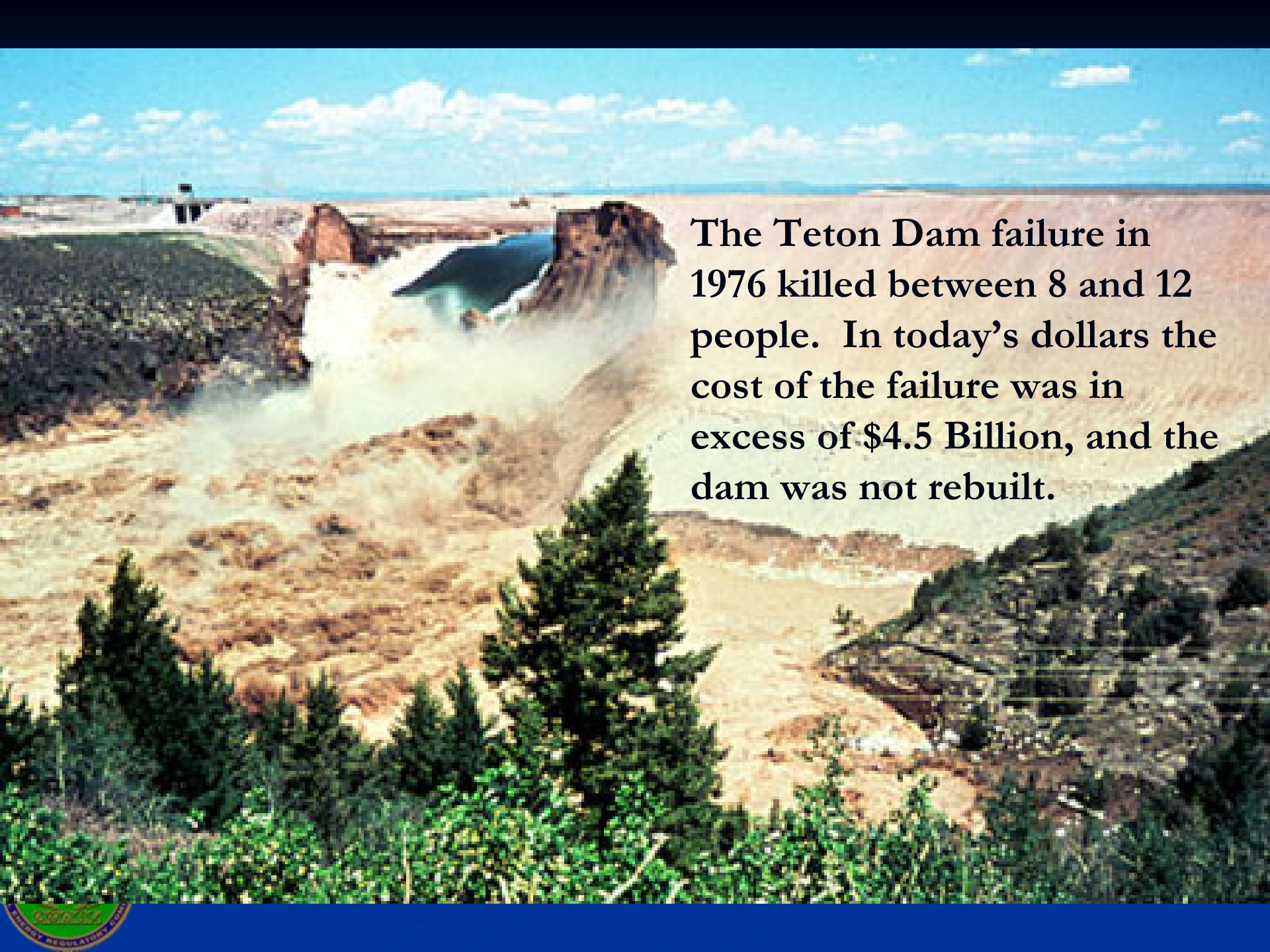
“A penalty of \$1 billion would be a ‘challenge’ to the utility . . . The company would have to sell additional stock to pay for a fine of that sum”

Anthony Earley, PG&E Chairman and Chief Executive Officer





The Taum Sauk Failure
cost Ameren more than
\$3 Billion in Direct and
indirect costs.



The Teton Dam failure in 1976 killed between 8 and 12 people. In today's dollars the cost of the failure was in excess of \$4.5 Billion, and the dam was not rebuilt.

Safety Culture

“The product that a gas utility sells is safe and reliable service. Delivering this product is the key to sustaining a utility’s franchise to service. It is also the basis for a utility’s reputation.”



Safety Culture

“A number of concerns surfaced in the course of our investigation that go to this issue of whether PG&E has a high functioning organization, capable of fulfilling its mandate for safe and reliable gas service.”



Safety Culture

“We think this failing is a product of the culture of the company – a culture whose rhetoric does not match its practices.”



Comparison of PG&E Annual Reports 2010

- 1) As a holding company, PG&E Corporation depends on cash distributions and reimbursements from the Utility to meet its debt service and other financial obligations and to pay dividends on its common stock.



Comparison of PG&E Annual Reports 2011

- 1) PG&E Corporation's and the Utility's reputations have been significantly impacted by the publicity surrounding the San Bruno accident and related investigations, and may be further adversely affected by current and future CPUC investigations or other regulatory, governmental, media or public scrutiny of the Utility's operations and negative publicity associated with the utility industry in general or PG&E Corporation and the Utility in particular. Such further reputational harm or the inability of PG&E Corporation and the Utility to restore their reputations may further affect their financial conditions, results of operations and cash flows.



Comparison of PG&E Annual Reports 2010

16) The Utility's financial condition and results of operations could be materially adversely affected if it cannot successfully manage the risks inherent in operating the Utility's facilities and information systems.



Comparison of PG&E Annual Reports 2011

- 8) The operation of the Utility's electricity and natural gas generation, transmission, and distribution facilities involve significant risks which, if materialized, can adversely affect PG&E Corporation's and the Utility's financial condition, results of operations and cash flows, and the Utility's insurance may not be sufficient to cover losses caused by an operating failure or catastrophic event.



Comparison of PG&E Annual Reports 2010

The Utility owns and operates extensive electricity and natural gas facilities that are interconnected to the U.S. western electricity grid and numerous interstate and continental natural gas pipelines. These interconnected systems are becoming increasingly reliant on evolving information technology systems, including the development of technologies and systems to establish a “Smart Grid” to monitor and manage the nation’s interconnected electric transmission grids. The Utility’s wide deployment of an advanced metering infrastructure throughout its service territory in California, in combination with the system changes needed to implement “dynamic pricing” for the Utility’s customers, may increase the risk of damage from a system-wide failure or from an intentional disruption of the system by third parties. The operation of the Utility’s facilities and information systems and the facilities and information systems of third parties on which it relies involves numerous risks, the realization of which can affect demand for electricity or natural gas; result in unplanned outages; reduce generating output; cause damage to the Utility’s assets or operations or those of third parties on which it relies; or subject the Utility to claims by customers or third parties for damage to property, personal injury, or the failure to maintain confidentiality of customer information.



Comparison of PG&E Annual Reports 2011

The Utility owns and operates extensive electricity and natural gas facilities, including two nuclear generation units and an extensive hydroelectric generating system consisting of approximately 170 dams, a pumped storage facility, numerous reservoirs, and many miles of canals, flumes, and tunnels. The Utility's service territory covers approximately 70,000 square miles in northern and central California and is composed of diverse geographic regions with varying climates and weather conditions that create numerous operating challenges. The Utility's facilities are interconnected to the U.S. western electricity grid and numerous interstate and continental natural gas pipelines. The Utility's ability to earn its authorized rate of return depends on its ability to efficiently maintain and operate its facilities and provide electricity and natural gas services safely and reliably. The maintenance and operation of the Utility's facilities, and the facilities of third parties on which the Utility relies, involves numerous risks, including the risks discussed elsewhere in this section and those that arise from:



Comparison of PG&E Annual Reports 2010

1. operating limitations that may be imposed by environmental laws or regulations, including those relating to GHG, or other regulatory requirements;
2. imposition of stricter operational performance standards by agencies with regulatory oversight of the Utility's facilities;
3. environmental accidents, including the release of hazardous or toxic substances into the air or water, urban wildfires, and other events caused by operation of the Utility's facilities or equipment failure;
4. fuel supply interruptions;
5. equipment failure;



Comparison of PG&E Annual Reports 2010

6. failure or intentional disruption of the Utility's information systems, including those relating to operations, such as the advanced metering infrastructure being deployed by the Utility, or financial information, such as customer billing;
7. labor disputes, workforce shortage, and availability of qualified personnel;
8. weather, storms, earthquakes, wildland and other fires, floods or other natural disasters, war, pandemic, and other catastrophic events;
9. explosions, accidents, **dam failure**, mechanical breakdowns, and terrorist activities; and
10. other events or hazards.



Comparison of PG&E Annual Reports 2011

1. the release of hazardous or toxic substances into the air or water;
2. fuel supply interruptions or the lack of available fuel which reduces or eliminates the Utility's ability to provide electricity and/or natural gas service;
- 3. the failure of a large dam or other major hydroelectric facility;**
4. the breakdown or failure of equipment, electric transmission or distribution lines, or natural gas transmission and distribution pipelines, that can cause explosions, fires, or other catastrophic events;
5. the failure of new generation facilities to perform at expected or at contracted levels of output or efficiency;



Comparison of PG&E Annual Reports 2011

6. use of new or unproven technologies;
7. the failure to take expeditious or sufficient action to mitigate operating conditions, facilities, or equipment, that the Utility has identified, or reasonably should have identified, as unsafe, which failure then leads to a catastrophic event;
8. operator or other human error;
9. cyber-attack;
10. severe weather events such as storms, tornadoes, floods, drought, earthquakes, tsunamis, wildland and other fires, pandemics, solar events, electromagnetic events, or other natural disasters; and
11. acts of terrorism, vandalism, or war.

