Nature's Effects on Electricity Infrastructure:
a Nuclear Regulator's Perspective

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Nature's Effects on Critical Electricity Infrastructure

1. Expectations are key

2. Events with Significant Negative Impacts *do* happen

3. How Do You Fix It When --
   1. Money is Infinite
   2. In the Real World

4. Conclusion
Expectations are Key

• To best prepare you have to understand what your users' or customers' expectation are.

• Then you either:

  • Design and *implement* a system that meets those expectations

  OR

  • Communicate *exhaustively* to bring expectations in line with your actual capabilities
Expectations are Key

• Examples of expectations for electricity infrastructure

• "Nuclear power plants should never have accidents"

• "Nuclear power plants will have accidents but my family will be safe even if they do"

• "My electricity should never go out during a hurricane"

• "My electricity should only go out in a hurricane if it is greater than category 1 storm"

• "It would be ok if my electricity goes out, if I have a portable generator"
Nature is a Powerful Force

- Storms with power outages are not uncommon throughout the United States.

- "Data from various studies lead to cost estimates from storm-related outages at between $20 billion and $50 billion annually. Data also suggest the trend in outages from weather-related events is increasing."

-- CRS Report, 8/28/12
The effects of natural hazards can be significant.

"The current rough estimate of the total cost to Japan from the Fukushima Dai-ichi accident is about $500 billion U.S. dollars, which will substantially increase if nuclear electricity generation continues to be replaced for a long time by other means."

-- "Forging a New Nuclear Safety Construct, ASME 6/14/2012"
Nature is a Powerful Force

• What do these examples suggest?

• Natural hazards that are most damaging come from combined effects of single events

  • Storm surge, rain and wind from a hurricane

  • Earthquake followed by a tsunami

• Economic costs alone can be staggering

  • Even routine occurrence have significant impact on daily activities -- no one like to be without electricity for very long

  • Large, catastrophic events can have national long-lasting impact
Nature is a Powerful Force

- Looking from the 30,000 foot level, we need to:
  - Ensure that we are imaginative in considering the types of holistic hazards that can come from natural events
  - Ensure that all qualitative and quantitative impacts are considered
How to Fix: the Infinite Money Solution

Redesign, replace and upgrade all transmission, distribution, and generation to ensure design and implementation are commensurate with expectations of customers for natural hazard situations.
How to Fix: the Infinite Money Solution

• There are three phases to a robust infrastructure (my take on the nuclear power model)

1. Prevent hazards from negatively impacting the infrastructure

• characterize the hazards that could affect the infrastructure

• design solutions to address all the hazards consistent with expectations

• implement the design without mistakes
  (remember: this is the perfect solution)
How to Fix: the Infinite Money Solution

2. Develop mitigation strategies to deal with unforeseen failures of the design elements and unforeseen hazards

- must be independent of the initial prevention measures
- must be implementable under extreme circumstances, i.e. without electric power or during strong wind storms
3. Develop response strategies in case both #1 and #2 fail

- could involve evacuation or relocation from the affected area

- may involve basic law enforcement functions and other local government responsibilities
How to Fix: the Real World

• With limited resources you either have to address the design OR address the expectations OR both

• Then you have to choose among the three steps and prioritize given finite resources of all types
How to Fix: the Real World

• Finite resources can manifest in many different ways
  • financial -- most obvious
  • technical skills -- seismologist with a working understanding of nuclear power plant probabilistic risk assessment
  • lack of understanding or imagination -- Fukushima accident?
How to Fix: the Real World

- the bad news -- in my experience there are really no methodologies to help you *objectively* determine how to allocate scarce resources

- Probabilistic risk analysis has weaknesses
  - not useful for low likelihood, high consequence events
  - not a decision-making tool, but an information tool

- Cost benefit hides subjective elements behind apparently *objective* financial calculations
  - Why is the financial benefit of limiting a person's exposure to radiation $2000 person-rem?
How to Fix: the Real World

• the good news -- much can be done to improve design and implementation AND recalibrate expectations

• requires strong collaboration between government, industry, public interest groups and the public

• communication, communication, communication
How to Fix: the Real World

- Smaller, modular, distributed is better
- The advantages are more redundancy, more localized damage, faster recovery
  - Distributed smart grid design
  - Smaller, modular nuclear facilities
- Must be coupled with appropriate new design standards for new investments
- Generally cheaper to design well than to modify electricity infrastructure later
Conclusion

• I believe the consumer's expectation for performance of electricity infrastructure to deal with natural hazards is inconsistent with current capabilities

• Systematic approach for critical electricity enhancements must involve extensive dialogue about design and implementation of enhancements AND reconsideration of expectations for performance

• There are opportunity and solutions to fix but it will take significant focus and rethinking of the design and implementation of our electricity infrastructure