A Japan's Challenge

– Towards Creating a Most Robust Nuclear Energy Future

PBNC2014

Vancouver, Canada

August 25, 2014

Atsuyuki Suzuki

Professor Emeritus, University of Tokyo

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Lessons Learned from the Fukushima Daiichi Accident

- **Why were only the Fukushima Daiichi Units 1-4 so fragile against the inundation?**

- EDGs with no engineered scheme for the common-cause failures.
- Missed opportunities to reflect on:
  1. new scientific findings on seismology in Japan obtained since 1995, when facing another massive quake. And,
  2. overseas experiences such as 1999 French La Blayais NPP prolonged heavy flooding.

- **An observation in the 2013 TEPCO's self-investigation report**

- A lack of adequate risk communication – the thought-stopping pattern, assuming a reactor shutdown is required, if risks are announced.
- Japan's uniqueness – an internal consensus-based society.

Information Asymmetry

- **2001 Nobel Prize in social economics**
- **Markets:** ***sellers are better informed about product quality than buyers*****.**
- **Behavioral economics:** ***what happens in the market with information asymmetry?; what can better-informed agents do to improve the market outcome?; and so on.***

- **Nuclear safety issues with the accident**
- **Information asymmetry between industries, regulators and the general public.**
- **One cannot exclude or eliminate it, but preferably should manage it adequately, not leading to a serious problem.**
- **What should utilities or industries do as a better-informed agent implementing the prime responsibility for ensuring nuclear safety?**

Adaptive Behavioral Actions

- **What is a robust nuclear energy system?**
- **The possibility: the nuclear safety system itself can be strengthened if adequately managing the information asymmetry issue.**
- **A robust nuclear energy system is based on such possibility.**

- **Herbert Simon's book: "Sciences for the Artificial," 1998**
- ***An intelligent system's adjustment to its outer environment, substantive rationality, is limited by its ability, through knowledge and computation, to discover appropriate adaptive behavior, procedural rationality.***
- **A key element is the human behavioral approach to having an interaction with its outer environment, the general public, for instance, in a way that a specific consideration is given to accommodate to the limitedness of its own substantive rationality, its own substantive safety system.**

<u>Safety Culture</u>

- **<u>IAEA 1991 safety culture document's warnings</u>**

- **The biggest danger is to oversimplify things in our minds, tempting us to say culture is just "the way we do things around here," or "our basic values," or "our rituals," and so on.**

- **<u>A tangible benefit</u>**

- **To cope with the danger, a tangible benefit is to be provided.**
- **An example: INPO's rating results on individual plant performance are reflected in determining the amount of insurance charges.**

- **<u>Balancing the transparency and the privacy</u>**

- **The INPO's evaluation process and results are not open to the public.**
- ***"The non-open system is designed so that criticism can be uninhibited and actions can be taken in a timely manner without fear of misinterpretation, under the firm commitment of the company with the prime responsibility."* (Blandford and May, 2012)**

Transparency

- **Suspicion between better-informed and less-informed agents**
- **Concerns on nuclear safety stems from suspicion between nuclear industry and the public.**
- **Transparency does *not* necessarily imply the amount of information disclosed *but* the effective measures alleviating the suspicion.**
- **A fail-safe self-organizational cross-checking system, i.e., a diagnostic system using a big data analysis technique seems promising.**

- **A communicative action for deliberation of a trans-scientific issue**
- **An example: revision of reactor seismic safety guidelines in Nuclear Safety Commission of Japan, 2001-2006**
- **100 committee meetings open to the public, and 1,000 public comments individually responded by the committee.**
- **The outcome was more successful and effective than otherwise.**

Alvin Weinberg(1972)"Science and Trans-science"

- **Trans-science, where science mostly means natural science**
- "***Many of the issues which arise in the course of the interaction between science or technology and society hang on the answers to questions which can be asked of science and yet which cannot be answered by science*.**"
- **The examples: severe reactor accidents and low-radiation dose**

- **The Fukushima Daiichi accident**
- **Insufficient consideration on tsunami safety, connected with severe accident**
- **The 2014 U.S.NAS Fukushima investigation report; the Japan's emergency response plans, particularly protective actions for special populations, such as ill, elderly people, were inadequate.**
- **The practical need for trans-scientific considerations on low dose risks: *not only* from the validity of LNT models, *but* from the psychological negative effects as well.**

Long-lived Radioactive Waste Management

- **The source for trans-scientific aspect**
- **Very long-term safety assessment inevitably associated with great uncertainties**
- **The robust model: calculated results can be estimated consciously on the side of safety**

- **How to manage it**
- **The recent progress in the Canadian program, occupying the attention of global community. Something like the need to have proactive reflection of the overseas operational experiences.**
- **The advancement of scientific knowledge and technology expected from challenging a socially more urgent long-lived waste issue which would require a political solution for its trans-scientific aspects in the nearer future.**
- **Japan should challenge it to assume a responsibility of the country where the accident took place.**

Concluding Remarks

- **In short summary**
- **A most robust nuclear energy future will be created only with appropriate adaptive behaviors, dedicated to strengthening the safety system that is vulnerable due to information asymmetry.**
- **Illustrated are: fail-safe quality management, performance rating by self-regulator with balancing transparency and privacy, communicative actions for regulations with utmost transparency, and overall risk communication, opposed to the psychological effect.**

- **Avoiding Hindsight Bias (S. Dekker, 2007)**
- **After an accident, easy to see where people went wrong, what should have done or not done, to judge people for missing a piece of information that turned out to be critical, and to see exactly the kind of harm that should have foreseen and predicted.**
- **Before an accident, such insight is difficult and perhaps, impossible**
- ***Avoiding hindsight bias* requires changing our emphasis in analyzing the role of human in accidents from what they did wrong *to why it made sense for them to act the way they did*.**