Unsafety: Systems Pathology of the Fukushima Nuclear Catastrophe

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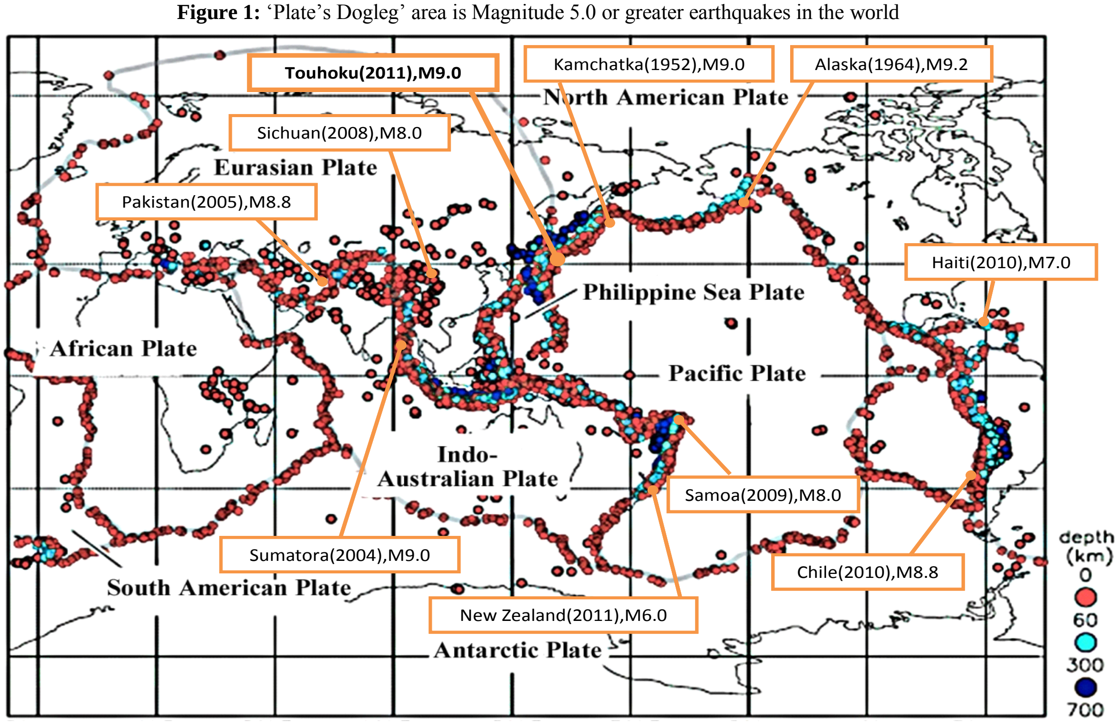
Introduction: Fukushima Nuclear Catastrophe 3.11

The magnitude 9.0 earthquake and tsunami that struck northeast Japan on March 11, 2011, were unavoidable natural disasters, but we consider the subsequent breakdown of the Fukushima nuclear power plants to be a catastrophe created not only by nuclear engineering systems but also by avoidable organizational errors – principally, neglect of nuclear safety issues without the necessary regulation both within the electric companies' management and from the level of governmental policy making. The present paper reviews, firstly, a complete re-thinking of the non-rational locations of atomic power stations, secondly, an analysis of the irrational decision-making of safety management and nuclear policy, finally, a rational proposal concerning the fade-out of nuclear power throughout the world. These proposals are made with a view to obtain sustainable decision-making for the future, not simply in light of the supply and demand of electrical power, but also in consideration of environmental aspects including the social system and the ecosystem. This article is not criticism against the electric company and their government.

I. 'Non-rational Location' near 'Plate-Dogleg' of the Earthquake-prone area

Figure 1 shows the world magnitude of plate-type earthquakes. We focus on magnitude near 9.0 since 2000. These big earthquakes form the pacific boundary that is 'Plate's Dogleg'.

Figure 1: 'Plate's Dogleg' area is Magnitude 5.0 or greater earthquakes in the world



Source: http://www.bousai.go.jp /hakusho/h22/bousai2010/html/zu/zu002.htm

The earthquake and tsunami that struck northeast Japan on March 11 of this year were natural disasters of unprecedented scale in modern Japan. More than 24,000 people lost their lives; about 100,000 people have evacuated the area; more than 250 billion dollars of damage was done; and it is expected that rebuilding the homes, businesses and infrastructure of a large section of Japan will take more than 30 years. While most of the time, energy and money should now be devoted to reconstruction, there are fundamental questions with regard to the failure of the nuclear power plants that demand to be answered. The starting point of our research is the question: Was the yet-unresolved Fukushima nuclear power plant accident an unfortunate natural disaster or an avoidable organizational disaster? For the reasons explained below, we conclude that it was a man-made ***catastrophe*** (Thom & Zeeman, 1966). The origins of the Fukushima nuclear catastrophe lie in systems pathology of the organizational system error.

II. 'Ir-rational Management' originating an Organizational Disaster with Mapping the World Nuclear Hazard

The organizational problems that have plagued the Fukushima nuclear facilities are of three kinds: frequent troubles because of the ageing of plants designed to last for a standard of 30 years (α), troubles due to the attempted concealment of events related to accidents and ageing (β), and the construction and later proliferation of nuclear plants in an area where earthquakes and tsunamis are known to occur (γ). Including these, there were also problems in safety management. In short, the functioning of "checks and balances" by administrative supervision has not worked well, and we must conclude that the Japanese system for nuclear power plant management has inherent organizational problems with regard to the decommissioning nuclear reactors.

(α) Age of Operations

The Fukushima Daiichi nuclear station includes 6 reactors, all of which are more than 30 years old (Table 1). To begin with, the lifetime of nuclear reactors is not specified by International or Japanese law. Even if a nuclear reactor is found to be ageing, power companies can operate it semi-permanently, provided that it passes industry-regulated maintenance inspections every decade.

Table 1: Ageing of Nuclear Reactors in Japan ⇒ α

Nuclear Power Plant Name	Period of Operation	Latest Permission
Tsuruga (West) reactor 1	**41 years** and 2 months	○
Mihama (West) reactor 1	**40 years** and 6 months	○
Fukushima Daiichi (East) reactor 1	**40 years** and 2 months	○
Mihama (West) reactor 2	**38 years** and 10 months	○
Shimane (West) reactor 1	**36 years** and 2 months	○
Fukushima Daiichi (East) reactor 2	**36 years** and 10 months	○
Takahama (West) reactor 1	**36 years** and 6 months	○
Genkai (West) reactor 1	**35 years** and 7 months	○
Takahama (West) reactor 2	**35 years** and 6 months	○
Fukushima Daiichi (East) reactor 3	**35 years** and 2 months	○
Mihama (West) reactor 3	**34 years** and 5 months	○
Igata (West) reactor 1	**33 years** and 8 months	○
Fukushima Daiichi (East) reactor 5	**33 years** and 1 month	○
Fukushima Daiichi (East) reactor 4	**32 years** and 7 months	○
Fukushima Daiichi (East) reactor 6	**31 years** and 7 months	○

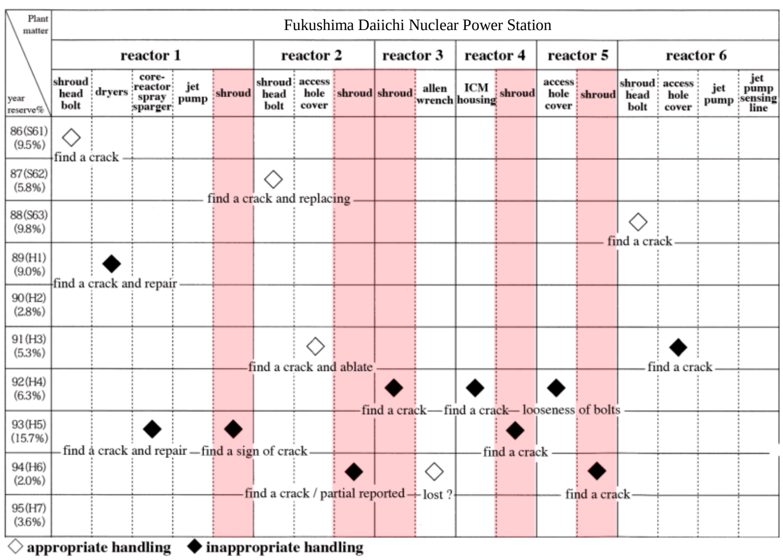
Source: Masai, 2009

The absurdity of this procedure is apparent from the fact that the Japanese Nuclear Industry Safety Agency granted permission to operate the No. 1 Fukushima reactor for more than 40 years on February 7, 2011 – approximately one month before the Fukushima disaster. And, 8 months after the Fukushima disaster with no resolution of the problem of spreading radioactivity in sight, on January 18, 2012 the Japanese government officially recommended decommissioning of current nuclear power plants limited until 40 years, but with exceptions up to 60 years.

(β) Troubles of Nuclear Reactors and un-disclosed

There were fully 206 disclosed troubles at the Fukushima power plants. Table 2 shows the reported hazards from exposure to radiation, such as "cracks in the nuclear reactor" and "loosening of bolts."(Nihon Kogyo Shinbun, 2003, p.14). The troubles were systematic, and the frequent inappropriate handling of the troubles and the complete absence of efforts to revamp the power plants from the ground up represent a lack of concern from the perspective of safety management. This has been the nature of the business ethics – or, rather, the lack of business ethics – exhibited by the Tokyo Electric Power Company over many decades. It is evident that Tokyo Electric Power Company's management places more importance on economical *growth* than on social welfare (Bertalanffy, 1976, pp.47-48).

Table 2: The Number of Technical Problems at the Fukushima Daiichi Nuclear Power Station.



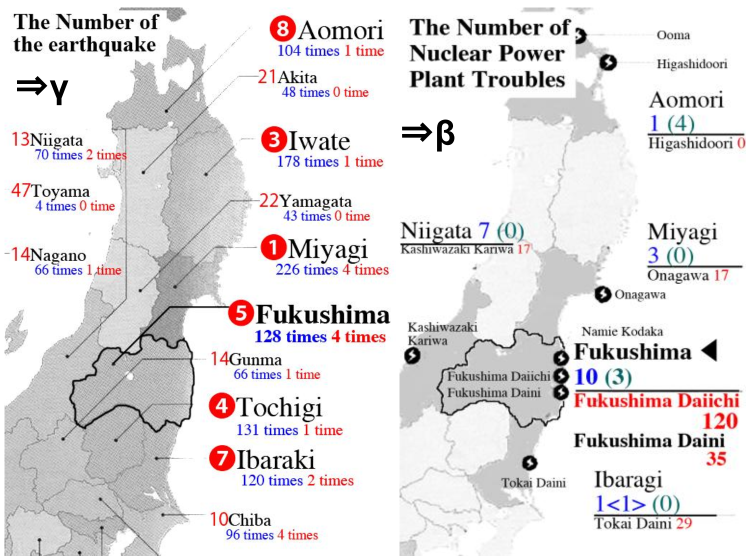
Source: Nihon Kogyo Shinbun, 2003, p.14

(γ) Magnitude of Earthquakes

The primary and fatal errors that led to the Fukushima disaster were made already in the late 1960s and early 1970s when the construction of multiple nuclear power plants on the northeast shoreline of Japan was approved. It is of course well-known that earthquake tremors are frequently felt in nearly all corners of Japan, but the historical record is unambiguous in indicating that the Tohoku Region has experienced the most frequent and most severe earthquakes in Japan, and is a region where catastrophic tsunamis have wiped out coastal towns and villages within recorded history. Magnitude 7~8 earthquakes have frequently occurred in the Tohoku region and the largest earthquake in Japan occurred in the same region about 1000 years ago, the so-called Jogan earthquake. It is consequently beyond understanding that specifically the shoreline of the Tohoku area would be chosen as the location for nuclear facilities.

As shown in Figure 2, the Fukushima nuclear power plants were set up in an area of highest earthquake probability in Japan. Furthermore, over the course of 40 years, there were fully 206 disclosed problems at these power plants, and a still-uncertain number of undisclosed problems.

Figure 2: The Number of the Earthquake and Troubles



Source: Masai, 2009, p.93, p.105

On the left is shown the incidence of earthquakes in the Tohoku Region (from 2008.9 to 2009.8). The number of earthquakes is shown below each location, followed by the number of earthquakes of seismic intensity more than 4. On the right is shown the number of operating (planned in parentheses) nuclear reactors, followed by the number of nuclear power plant troubles.

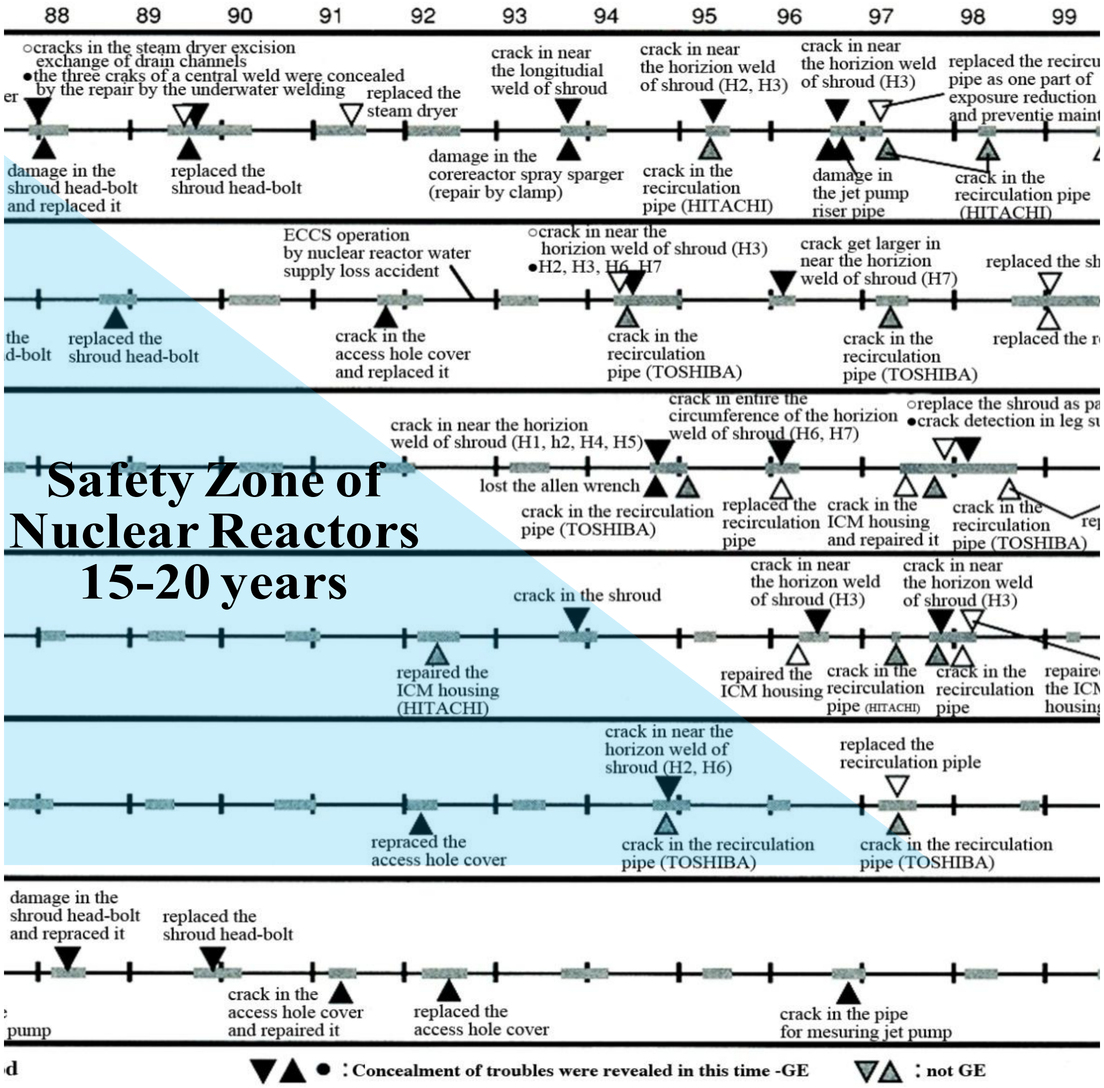
The relative proximity of the Tohoku region to the industry-dense, power-hungry regions of metropolitan Tokyo was of course a prime factor in the selection of sites for power plants. The low cost of rural land, the likely economic benefits of building large facilities in the Tohoku region and the absence of an effective, populist opposition to the construction of nuclear power stations were also relevant factors. But, what the power companies and politicians could not provide on their own was a convincing argument concerning the safety of the facilities. For that reason, they needed to solicit the advice of geologists and nuclear physicists for objective, disinterested, scholarly approval of the construction plans.

(ρ + τ) Factors Related to Social Systems as Safety Management: ρ, Dependability of Nuclear Policy: τ

The Fukushima catastrophe was a consequence of not only a natural disaster, but also organizational problems that led to the hiding of nuclear troubles by electric companies and the absence of relevant data that should have been considered by the supervisory politics. In effect, the safety of nuclear systems can be guaranteed by considering among the engineering technology with safety management of private sector and public administration for nuclear policy. The Fukushima catastrophe occurred because of a failure of corporate management and the failure to separate the government's role as the supervisory authorities against business concerns. TEPCO has a history of hiding many serious troubles at the Fukushima atomic power stations and this history indicates a loosening of ‘Morality or Ethics’. The loose supervisory role of the government allowed for a lack

Figure 3: Concealment of troubles and falsification in the records by TEPCO and GE.

Source: Genshiryoku siryoushitu, Iwanami No.582, 2002, p.7.
Statically, the blue shade is the safety zone of nuclear reactors – generally suggesting that the trouble-free period is somewhat less than 20 years.



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Safety Zone of
Nuclear Reactors
15-20 years
○cracks in the steam dryer excision
exchange of drain channels
●the three craks of a central weld were concealed
by the repair by the underwater welding
replaced the
steam dryer
crack in near
the longitudial
weld of shroud
crack in near
the horizion weld
of shroud (H2, H3)
crack in near
the horizion weld
of shroud (H3)
damage in the
shroud head-bolt
and replaced it
replaced the
shroud head-bolt
damage in the
corereactor spray sparger
(repair by clamp)
crack in the
recirculation
pipe (HITACHI)
damage in
the jet pump
riser pipe
crack in the
recirculation pipe
(HITACHI)
ECCS operation
by nuclear reactor water
supply loss accident
○crack in near the
horizion weld of shroud (H3)
●H2, H3, H6, H7
crack get larger in
near the horizion
weld of shroud (H7)
replaced the
shroud head-bolt
crack in the
access hole cover
and replaced it
crack in the
recirculation
pipe (TOSHIBA)
crack in the
recirculation
pipe (TOSHIBA)
crack in near the horizion
weld of shroud (H1, h2, H4, H5)
crack in entire the
circumference of the horizion
weld of shroud (H6, H7)
lost the allen wrench
crack in the recirculation
pipe (TOSHIBA)
replaced the
recirculation
pipe
crack in the
ICM housing
and repaired it
crack in the
recirculation
pipe (TOSHIBA)
crack in the shroud
crack in near
the horizon weld
of shroud (H3)
crack in near
the horizon weld
of shroud (H3)
repaired the
ICM housing
(HITACHI)
repaired the
ICM housing
crack in the
recirculation
pipe (HITACHI)
crack in the
recirculation
pipe
crack in near the
horizon weld of
shroud (H2, H6)
replaced the
recirculation piple
repraced the
access hole cover
crack in the recirculation
pipe (TOSHIBA)
crack in the recirculation
pipe (TOSHIBA)
damage in the
shroud head-bolt
and repraced it
replaced the
shroud head-bolt
crack in the
access hole cover
and repaired it
replaced the
access hole cover
crack in the pipe
for mesuring jet pump
pump
▼▲●: Concealment of troubles were revealed in this time -GE
▼▲: not GE

of TEPCO's 'compliance', without 'corporate governance'. The measurement of nuclear security is possible by applying the credit ratings of corporation and government, such as that of Moody's and Standard & Poor's, as a proxy for dependability of each corporations and by using the same evaluating supervisory authority that is used for evaluating government bonds (with an example, AAA=3, AA=2, A=1, and so on). A leading figure in academia, L. von Bertalanffy paid great attention to these aspects of hierarchical systems from physics to biology and C.I. Barnard emphasized that "Executive functions are the creation of a 'moral code' by integrating individual private codes into a social public code".

In Figure 3, the filled-in black triangles show the concealed events prior to 2002. Tokyo Electric Power Company did not announce these events in spite of the fact that troubles were experienced at all of their reactors. For example, they found cracks in the 'shroud' which is the cylindrical stainless steel cover that surrounds the reactor core, but did not report the actual number of cracks. In addition, from the number of occurrences of trouble, it is evident that nuclear reactors No.3, No.4, and No.5 operate with more stability than No.1 or No.2. As of 1986, 15 years had elapsed since reactor No.1 began operations. In Reactor No.3, the first trouble occurred 20 years from the beginning of operations. No.4 and No.5 experienced troubles after 14 years. In light of these experiences with Reactors 1-5, it can be said that the period of stable operation for these nuclear reactors is about 15-20 years. Unfortunately, if the life of a nuclear power plant is limited to just 20 years, the total cost of nuclear power generation is high, because maintenance and decommissioning will entail a huge expenditure. For this reason, many Japanese Electric Power Companies are in un-competitive situations, and, as a result, the companies are necessarily motivated not to make timely decisions about decommissioning even when circumstances indicate the reality of technical problems.

(ε) Fukushima Formula as Organizational Disaster indicator

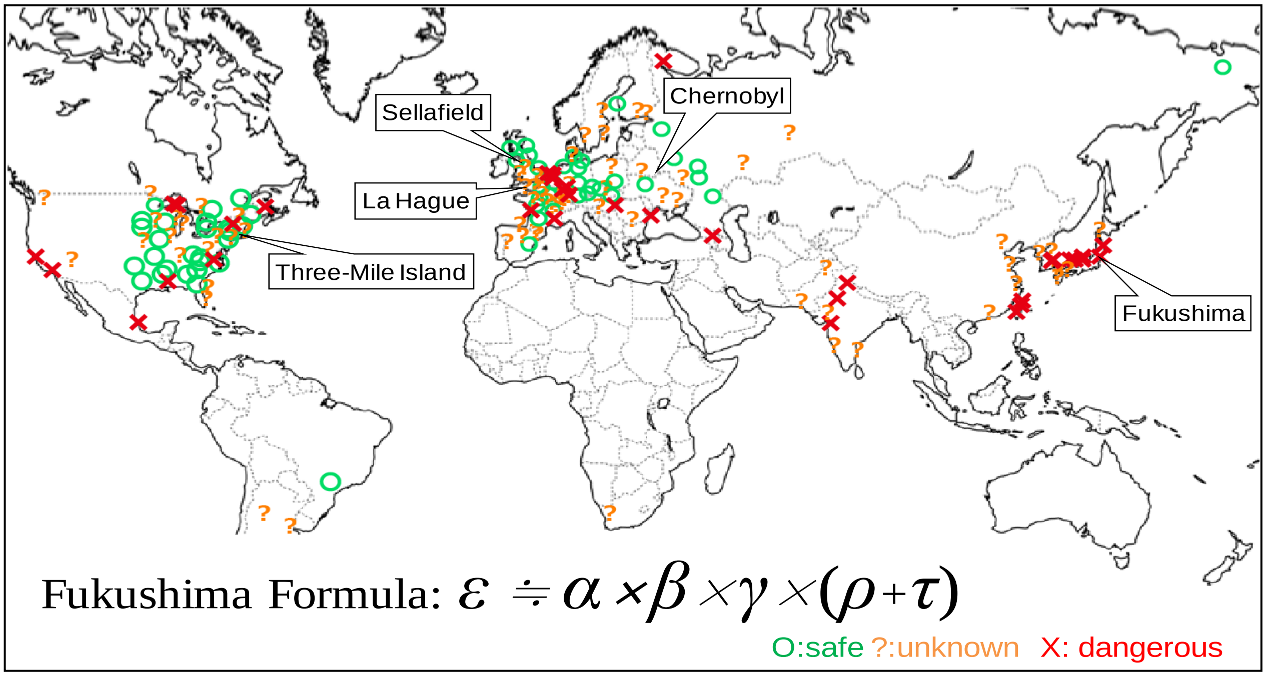
In light of the current Fukushima disaster, we believe that Japan should take on the mission of establishing new safety guidelines for the operation of nuclear reactors. Specifically, we suggest a decommissioning standard for nuclear fission reactors, based on the empirical data from Fukushima. A decommissioning formula has been constructed, as follows:

$$\varepsilon = \alpha \times \beta \times \gamma \,/\, (\rho + \tau)$$ Fukushima index: $\varepsilon \fallingdotseq$ Ave.141

The 'Fukushima Formula' relies on five variables, for which empirical data are readily available: the operating age of the reactor (α), the number of reported troubles of the nuclear system (β), the magnitude of earthquakes in the vicinity of the reactors (γ), and estimation of systemic fatigue in organizational management and the lack of clarity concerning nuclear policy ($\rho + \tau$). For instance, if the organizational factors related to the Fukushima case ($\rho + \tau$) are taken as 1.0 then the index of the Fukushima Daiichi Reactor 1 is calculated as: ε=216 from α=40, β=1.6/year, γ=4.

Figure 4 shows the locations of nuclear power plants in relation to the known dangers of plate-type earthquakes (magnitude ~9.0 earthquakes since 2000). We have adapted the Fukushima's decommissioning formula (previously advocated by us, Atsuji et al., 2011) to all nuclear power stations where relevant data are available. Figure 4 shows the results when the value of Fukushima case is applied to nuclear reactors worldwide. Note the high-incidence of dangerous facilities along the Pacific rim.

Figure 4: Hazard Map of world nuclear reactors applying the ‘Fukushima Formula’

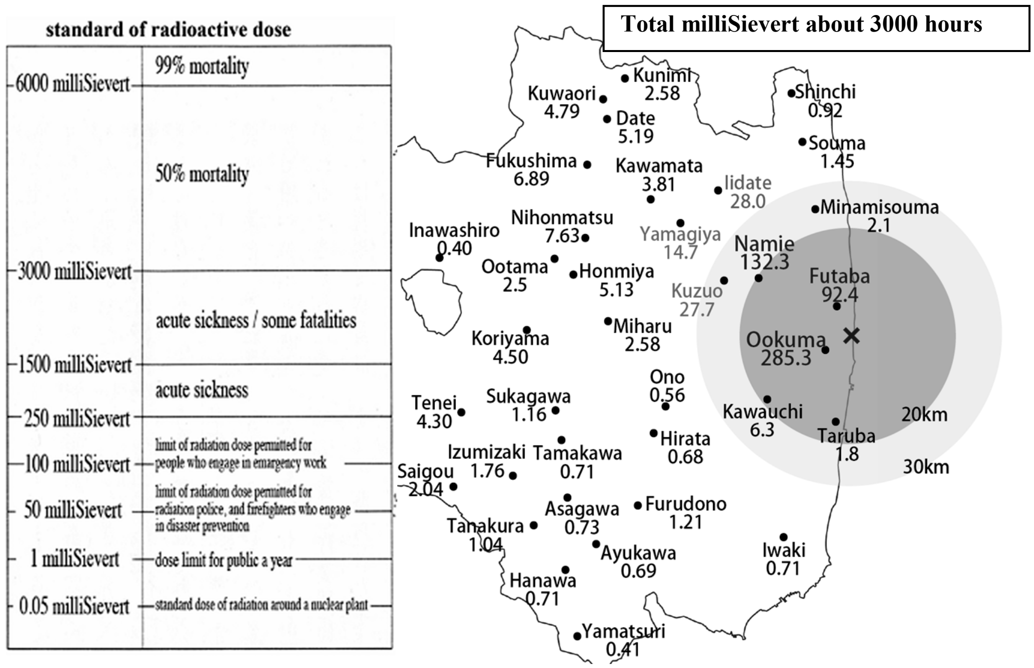


Our hazard map corresponds well in the Wall Street Journal (‘U.S. nuclear reactor proximity to high earthquake risk areas,’ 20 July, 2011).

III. ‘Limits of Administration’ after Nuclear to the ‘Radioactive Area’ from Chernobyl to Fukushima

The response of the Tokyo Electric Power Company and the government to the nuclear power plant disaster has clearly not been sufficient. The disclosure of ambiguous, contradictory and incomplete information has only added to the fear and suffering of the victims. We have calculated the total milliSievert exposure over the first 3000 hours since the tsunami. Figure 5 shows that the radial distance from a nuclear power plant is an unreliable measure of the danger zone. Outside the area of evacuation that the government has established, radiation doses much above normal have been recorded, for example, in Koriyama and Tenei. Notably, measurements at prefectural schools indicate that five places exceed the provisional standard value that the government established – 3.8 micro-sieverts – and there are many points where doses of radiation of 2-3 micro-sieverts per hour have been detected. The Government decided on a provisional radiation standard for schoolyards of "20 milli-Sieverts per year". That standard was based on the ICRP's recommendation for adults, but can it be applied to children, as well? A special advisor to the Cabinet's nuclear engineering specialists noted the danger, and subsequently resigned. Nevertheless, the schools located outside the evacuation zone in Fukushima Prefecture continue to carry out classes as usual. Clearly, it is necessary to disclose information, not only for the needs of governmental administration, but also for the needs of residents in areas affected by natural disasters.

Figure 5: Radiation Map of Fukushima



On the left is shown damage due to radiation exposure. On the right is shown the geographical distribution of radiation around Fukushima reactors since March 11.

From a global perspective, it is also important that new international standards be applied to the nuclear power stations currently under construction or planning in the developing world, notably, China and India. Table 3 shows the current state of developments in six of the major nuclear power generating countries. Prior to the recent disaster, Japan operated 54 nuclear reactors, but three quarters have now been stopped. Although it was once said that the level of Japanese nuclear technology was the highest in the world, pervasive problems in management and policy have become evident. In order to avoid repetition of the Fukushima disaster or worse disasters (Chroust, 2011) in the developing world, the enforcement of firm, quantitative standards by *independent* regulatory agencies will be required. In the other hand, if occurred the nuclear catastrophe in India and China, expand to radioactive contamination to the westerly the prevailing westerly of East Asia.

Table 3: A Comparison of Nuclear Systems Worldwide

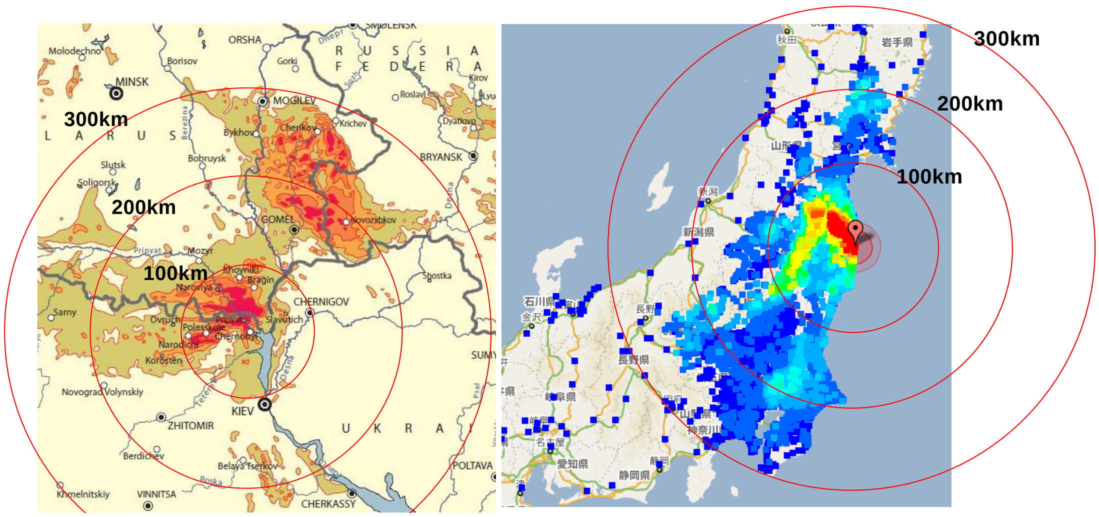
	In operation	Under construction	In planning	Average age
Japan	54	4	11	24
China	13	30	23	26
India	19	8	4	18
Russia	28	11	13	27
USA	104	1	8	30
France	58	1	0	24

Source: JAIF 2011

The Fukushima nuclear power station has continued to operate in spite of signs of ageing and, indeed, until the recent disaster, three new reactors had been scheduled to be built in the same location without first decommissioning the old reactors. The damage of this accident has not been confined solely to the local populace's exposure to radiation; there has also been significant damage to international relations. Various foreign countries have expressed misgivings about the spread of radioactive substances within Japan and their possible spread overseas. Two months following the natural disaster, the damage has continued to enlarge both economically and socially to the entire country. Moreover, the international community has clearly lost confidence in Japan's ability to respond effectively to domestic problems. On the basis of the Fukushima example, local people can judge the risk of nuclear reactors in operation.

The following Figure 6 shows a comparison between the Fukushima and Chernobyl disasters. On April 12, 2011, the Fukushima nuclear disaster was raised to INES level 7, the same as Chernobyl nuclear disaster.

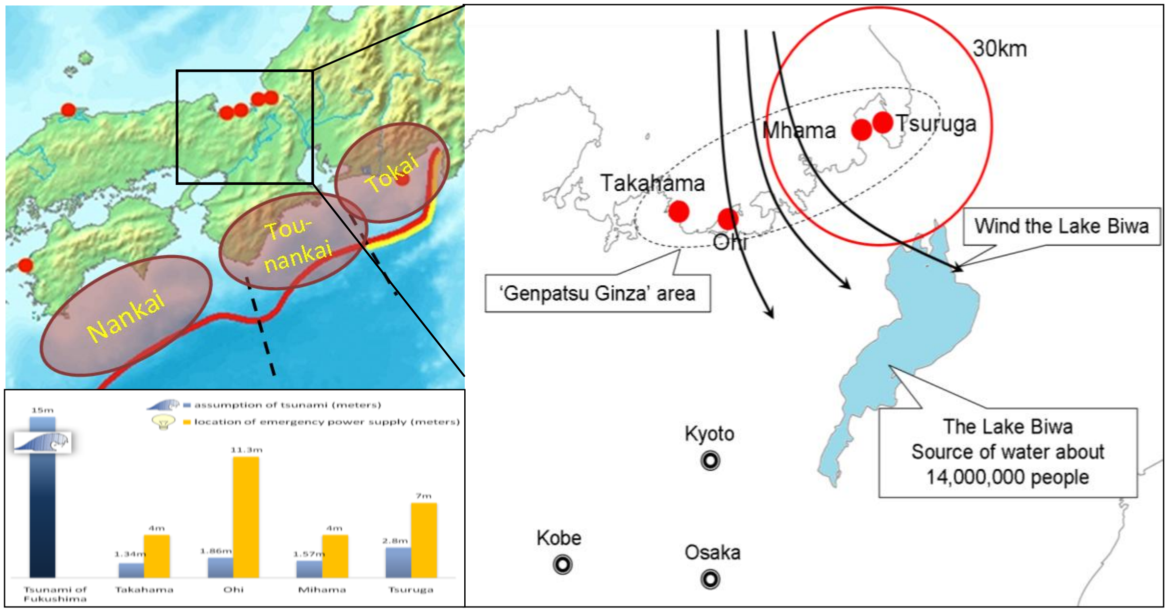
Figure 6: Radiation area of Chernobyl and Fukushima



Source: Chernobyl: IAEA(1991) Chernobyl Project Technical Report. Fukushima: www.nnistar.com/gmap/fukushima_temp.html

Applying west-Japan, on August 22, 2011, the risks of an earthquake occurring in western Japan were reported by 'The Coordinating Committee for Earthquake Prediction Japan'. According to this report, there is the danger of a large earthquake of the M9.0 class occurring on the Pacific Ocean side where the Tokai, Tonankai and Nankai earthquakes previously occurred. No new risks to Eastern Japan were noted in the report, but it focused on the dangers of earthquakes in Eastern Japan. However, if the next earthquake occurs in Western Japan, the Genpatsu Ginza nuclear stations could have a disastrous effect on Lake Biwa, which is that located only 30 km southeast of these nuclear power plants. Lake Biwa, the biggest lake in Japan, is the source of water in western Japan, providing fresh water to 14 million people. In addition, the prevailing wind blows from the Genpatsu Ginza toward Lake Biwa. The Genpatsu Ginza includes 13 nuclear power plants, which were constructed three or four decades ago (Tsuruga, 41 years ago; Mihama, 40 years ago; Takahama, 36 years ago; and Ohi, 32 years ago).

Figure 7: The three troughs forecasting in Western Japan



Above is shown the 'Genpatsu Ginza' area in western Japan and prevailing wind blowing toward Lake Biwa. Below is shown height of the seawalls and emergency power in place at these reactors.

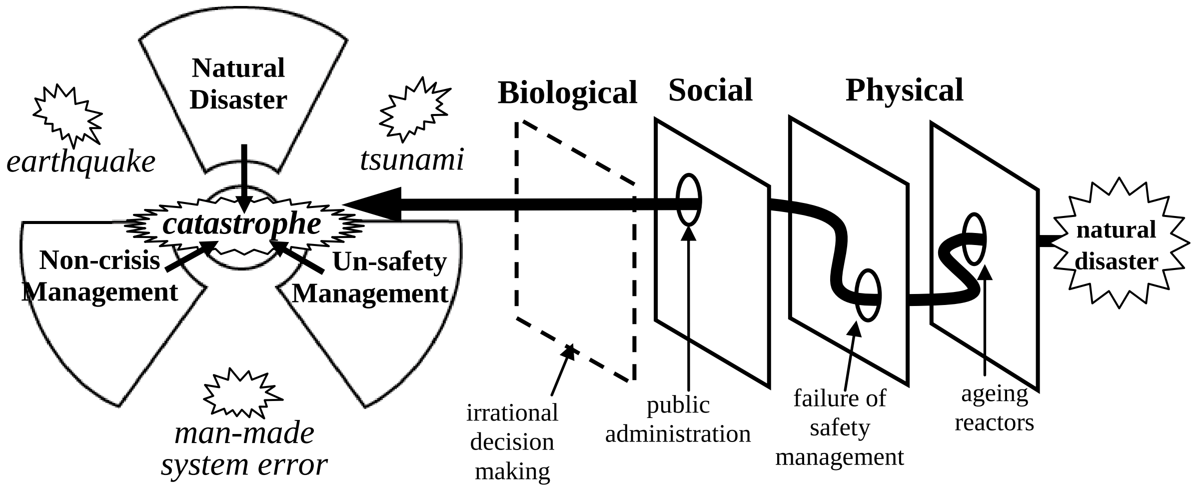
Figure 7 shows the height of the Genpatsu Ginza's seawalls (blue bars in the graph), and the height of the emergency power supplies (yellow bars). The tsunami at the Fukushima Daiichi Station was more than 15 meters, whereas the seawall was 5.7 meters. In recent history, relatively small tsunamis struck the coast of the Japan Sea, Nihonkai-Chubu Earthquake (1983. M7.7), Hokkaido Earthquake (1993. M7.8) and Niigata Earthquake (2004. M6.8), but the recent events in Fukushima suggest that the seawalls are dangerously low.

Insufficient disclosure of information to the residents in the affected area has also become a problem. Although the scale of this earthquake was beyond expectations, many problems have arisen in response to the natural disaster and the extreme vulnerability of countermeasures to the catastrophe was exposed. We recommend that, in the near future, organizations should shift from policy that gives priority to economic profits to policy where safety management and long-term sustainability becomes paramount. Nuclear power generation holds a *dominant* position relative to other means of generating electricity – hydropower, thermal power, wind power, solar power, geothermal power, tidal power – but the dominance is based on the presumption that nuclear reactors have a longevity of at least 40 years. Actually, the cost of constructing nuclear reactors is necessarily high, so that the first 20 years of operation is essentially a period of regaining the initial investment. If, however, the stable lifetime of nuclear reactors is only 20 years, as suggested by the Japanese history of nuclear power generation, then nuclear technology becomes uncompetitive in comparison with other power generation technologies.

IV. A Possibility of 'Eco-Management': Nuclear Fade-out for the Sustainable Society

To summarized: the Fukushima nuclear catastrophe is an example of the pathology of organizational systems with multiple causes and effects, and entails problems of social responsibility and the dangers of failing to maintain a distinction between public and private sector of social organizations. The current disaster indicates the need for a paradigm shift toward 'trust or dependability of nuclear safety' – a view emphasized by Barnard (1938) concerning the complex interactions among physical, biological, and social factors involved in complex organizations: '*a system of consciously coordinated activities or forces*'. By applying Bertallanfy's systems thinking with Reason's (1997) ideas on error management, Figure 8 illustrates how the accumulation of system errors make the occurrence of catastrophes possible.

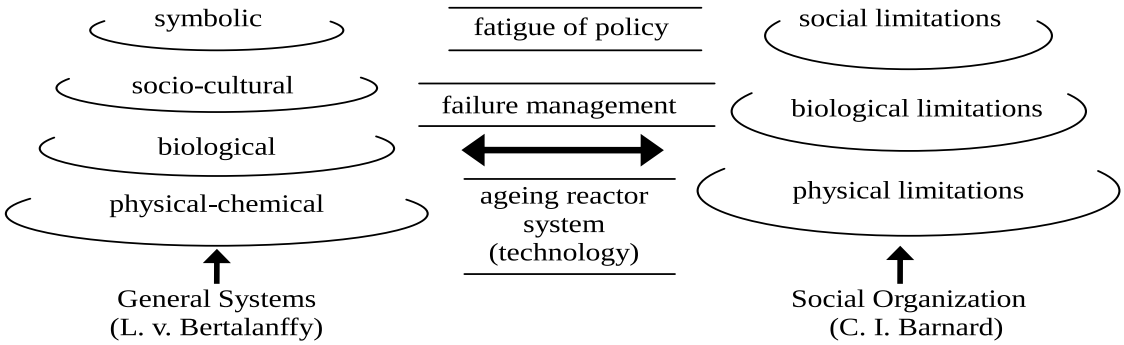
Figure 8: 'Triple Disaster' as Fukushima Nuclear (after Reason, 1997)



In the Fukushima case, the supervisory authorities of nuclear power generation in Japan are a double administrative structure. One is a Cabinet Office (Japan Atomic Energy Commission and Nuclear Safety Commission of Japan) and the other is the Ministry of Economy, Trade and Industry (Nuclear Industrial Safety Agency). The reality of multiple supervisory committees makes it unclear where responsibilities lie. Moreover, the practice of former government officials finding employment in the private sector is a widespread problem. Five persons who acted as supervisory authorities later became directors of the Tokyo Electric Power Company (The Mainichi Daily News, April 15, 2011). Clearly, the social function of overseeing the safety of the nuclear power industry has declined and there is a strong possibility that the friendly relations between the supervisory authorities and the industry have had deleterious effects on their watchdog role.

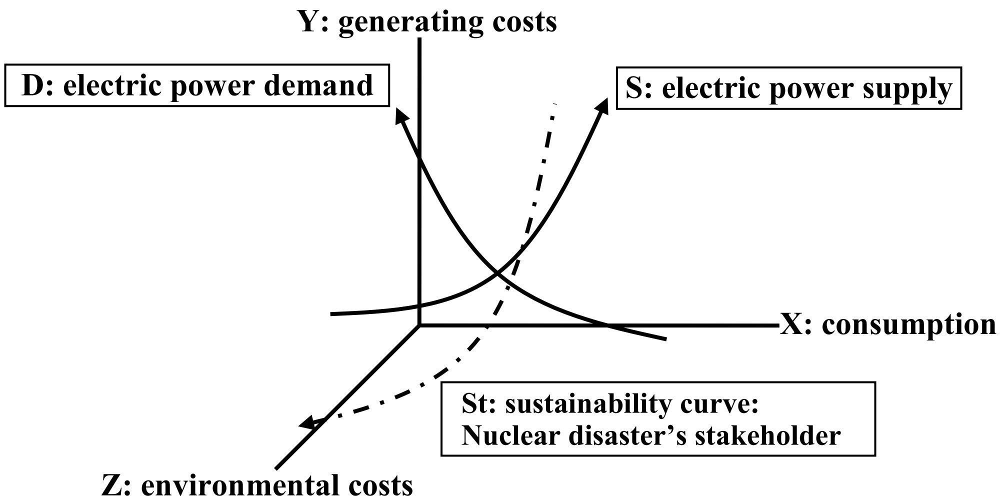
'Shell melt-through' generally means 'melt down'. This occurred already about 1 hour 40 minutes following the earthquake due to a loss of back-up electric generation for the cooling operation. The possibility of this danger had already reported by the Japan Nuclear Energy Safety Organization in October, 2010 (JNES, 2010, p.(4)-7). Although the nuclear policy explicitly states that "even if the probability is low, it is necessary to take steps to remedy possible dangers," measures were not taken. According to the report of the Nuclear Industrial Safety Agency (NISA, 2010, p.1), serious violations of nuclear waste management in nuclear reactors No.1, No.3 and No.5 of the Fukushima Daiichi Nuclear Power Station were pointed out. Moreover, one level 2 violation was pointed out with regard to nuclear waste management, but the troubles were concealed and records falsified by both the Tokyo Electric Power Company and General Electric.

Figure 9: The multiple levels of factors that must be considered in a system's approach to the governance of nuclear power stations



Finally, figure 9 is worth repeating the fundamental idea that initiated the revolution in Bertallanfy's systems theories and Barnard's 3 limitation of human nature (Bertallanfy, 1976; Barnard, 1937). The desirability and viability of nuclear power plants cannot be evaluated without consideration of the social systems in which they are embedded. The supply-and-demand decisions for economic growth are a necessary part of any social policy, but the wider effects on humanity must also be included. Realistic estimates of the sustainability of the "whole system" require a "systems" perspective (Figure 10).

Figure 10: 3D-Utility of Power Generation

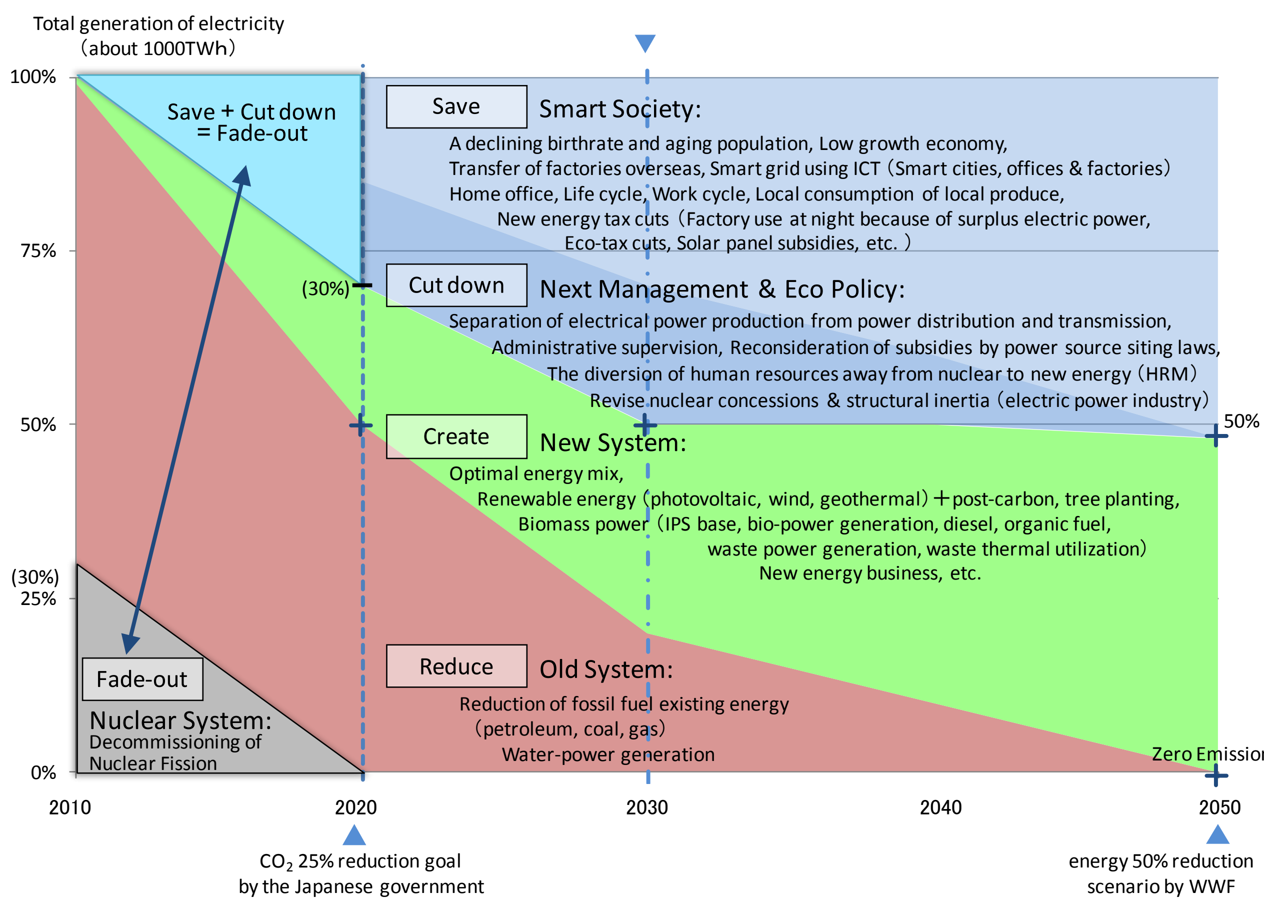


(restoration for the radioactive damage of ecosystem - including the human society in environment)
Stakeholders: Recovery of radiation area with local people's health, agriculture and marine pollution.
Regulation or administration with stakeholder and interests to security market of Electric Companies stock and share with freezing capital and assets, stopping the securities exchange.

In light of the Japanese experience, it can be said that decision-making based solely on supply-and-demand was the cause of system pathology. The economic viability of the large-scale nuclear fission power plants that were designed prior to developments in systems theory – and, indeed, prior to the development of modern computers – is questionable. Moreover, they have proven to be vulnerable to natural disasters. When the economy of nuclear power generation is discussed, the problem of radiation poisoning should not be excluded. For example, the construction cost of a new shelter of the Chernobyl Nuclear Power Plant is 1.6 billion euro, and the maintenance costs are additional. Ukraine cannot pay these costs. Nuclear power generation is not economical and not a sustainable technology if we consider the radiological processing costs and environmental stress. To summarize, the following are organizational problems that could have been avoided. Firstly, the nuclear power plant was constructed in an area where many earthquakes and several tsunamis have occurred. Secondly, there has been a significant number of nuclear power plant troubles due to ageing and, moreover, systematic concealment of those problems. Thirdly, there has been a long-term deterioration of organizational systems, like the safety management of Tokyo Electric Power Company and problems of the administrative supervisory role. At the very least, in the future the Japanese Government and the Tokyo Electric Power Company should disclose accurate information to facilitate local recovery, such that the disclosure of information can be trusted and there is greater faith in the power companies and in the government. This will also help to reduce damage caused by rumours by overseas media.

Following the 'Fukushima catastrophe', the consciousness of denuclearization has increased not only in Japan but also worldwide. Nuclear policy is under active reconsideration in EU countries, especially Germany, because of 'unforgettable Chernobyl,' but it is impractical to decommission all nuclear reactors immediately. Prior to decommissioning, alternative sources of energy must be developed for economic and social sustainability. We suggest a schedule for the fade-out of nuclear fission plants, as shown in Figure 11.

Figure 11: Japanese electricity scenario of the fade-out plan of nuclear by Atsuji Seminar



The scenario is synchronized with the 2020 goal of 25% reduction in CO_2 by the Japanese government and the WWF's goal of 'zero emissions' by 2050.

In 2010 Japan, the percentage of nuclear power supplied to the total electric grid was about 30%, while the contribution from 'renewable energy' (e.g., photovoltaic, geothermal, bio-power, waste power generation) was less than 1%. Because the technical developments needed for an increase in renewable energy sources inevitably take a long time, we focus on means for 'cutting down' plus 'saving' that are equivalent to the nuclear electricity supply. A particularly important problem for the attenuation of electricity to 50% is the separation of electrical power production from power distribution and transmission. In our trial calculations, such developments could make up for nuclear generation of electricity, and the complete fade-out of nuclear power by means of the fission of Uranium and Plutonium can be realized by 2020. With regard to the 25% reduction in CO_2 production, as envisioned by the Japanese government, it is clear that CO_2 can be reduced when alternative energy sources compensate for fossil fuels. By 2050, electric power will be reduced by 50% and the remaining 50% will be generated by alternative energy sources, WWF called 'Zero emission' energy.

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