Nuclear Power is not the Answer to Climate Change Mitigation

Book · January 2014

CITATION
1

READS
54

4 authors, including:

Jusen Asuka
19 PUBLICATIONS **66** CITATIONS
SEE PROFILE

Toru Morotomi
University of Michigan
2 PUBLICATIONS **3** CITATIONS
SEE PROFILE

Reply to the letter from Dr. Hansen and others

Nuclear Power is not the Answer to Climate Change Mitigation

January 31, 2014 (ver.2)

Jusen ASUKA, Professor, Tohoku University*

Seung-Joon PARK, Associate Professor, Kwansei Gakuin University

Mutsuyoshi NISHIMURA, Former ambassador for the United Nations climate change negotiations

Toru MOROTOMI, Professor, Kyoto University

Dear Doctors Caldeira, Emanuel, Hansen and Wigley

Please allow us to introduce ourselves as Japanese academic researchers working on the studies and policy recommendations for the mitigation of climate change issues from economic and political perspectives. We are writing this letter in response to your letter "To those influencing environmental policy but opposed to nuclear power" (Caldeira et al., 2013).

First of all, we would like to express our sincerest commendation and utmost respect to all the extremely serious work you have accomplished thus far on the study of climate change issues. At the same time, however, because of the severe nature of the nuclear disaster that occurred in Fukushima on March 11 2011, we, as members of Japanese society, inevitably have certain reservations on your viewpoints placing greater emphasis on the role of nuclear power generation in climate change measures.

The main reason of our reservation is because we believe in the need for a thorough review of the argument for "the need of nuclear power generation due to the seriousness of climate change issues." It is certainly not a simple matter to compare the risks posed by nuclear power generation with those of other energy sources and environmental problems. When discussing the risks of nuclear power generation, we must bear in mind the fact that any major accident at a nuclear power plant may have irrevocable consequences. In this sense, we believe that you and others may have underestimated the risks of nuclear power generation, while also underestimating the possible role of other climate change measures, such as fuel switching, renewable energies, and energy saving. As we will state in the latter part of this letter, we have found arguments by climate change skeptics are taking stronger root in the political forum in Japan, much more than what you may have imagined. They argue that climate change mitigation is a plot originated by the nuclear power industry to promote nuclear power. That is why we, as Japanese researchers, have emphasized the need and the potential of a universal solution to remove

* Corresponding email address: asuka@cneas.tohoku.ac.jp (J.Asuka)

† As of Jan. 31, 2014, 1 Japanese yen is approximately 0.975 US cents.

both the risk of nuclear power and the risk of climate change. We are very much concerned that a letter from such prominent scientists like yourselves, advocating nuclear power generation as a climate change measure may give power to the arguments of such skeptics and eventually defeat your purpose of promoting better understanding of the need for climate change measures.

In the following pages, we will like to point out what we consider the risks of nuclear power generation, its costs and new types of reactors, as well as the potential for further climate change measures without relying on nuclear power, while also introducing the current situation in Japan. We sincerely hope that this information will be helpful to you as you continue to further your research work for climate change measures.

Contents:

1. Probability of nuclear accidents

What is important when comparing the risks and safety factors of nuclear power generation with those of other energy resources is the probability of major accidents at nuclear power plants. As is well known, Nordhaus (1997) made a detailed analysis on the rationale of non-nuclear policies in Sweden. The presumptions of his works, however, included that "the probability of risks to have severe accidents resulting in a melt-down would be once in a million reactor years (one reactor year is one year operation of one reactor) to once in a hundred million reactor years." However, such a small numerical result was simply due to the use of a simulation of Probabilistic Risk Assessment (PRA), and at the same time what was considered as a "safety target" by the International Atomic Energy Agency (IAEA). The Japanese nuclear policy has failed because both the administrative and judiciary branches of the government believed in such numbers as "the proof of safety." The results of the Probabilistic Risk Assessment such as event-tree analysis, was merely a relative number aimed to improve nuclear power plants by overcoming their weaknesses. It was not a number to be used or to be taken as the absolute "proof of

safety."

What if we were to propose to an insurance company, which is a professional entity with regard to risk assessment, to set nuclear power damage insurance at an extremely low insurance rate based on this kind of accident probability number? You can be sure that no insurance company would ever be likely to sign such an insurance policy.

Here, we would like to let you know how the Japanese Nuclear Insurance Pool set their insurance rate in 1997, several years before the accident in Fukushima. At that time, the insured amount for damage compensation was only 30 billion yen (ca. 0.3 billion dollars[†]) for each site (actual cost of Fukushima accident will be no less than 10 trillion yen). Furthermore, conditions were set such that that insurance could be exempt from payment of compensation in the case of accidents due to earthquake, tsunamis, volcanic eruption, etc., based on the Japanese laws. In 1997, insurance fees of about 2.3 billion yen were paid to insurance companies for 23 nuclear plant sites, which works out at 0.1 billion yen per site. Considering this figure as an approximate pure insurance fee, it showed that insurance companies estimated that the probability of an event causing 30 billion yen's worth of damage, such as the situation when radioactive materials were emitted externally, would be once in about 300 years per site even without the accident caused by natural disaster. In other words, if insurance companies considered an insurance fee based on the aforementioned probability of once in 10 million years, then the insurance fee would be about 3000 yen per site. However, they did not do that.

After the Fukushima accident, the Nuclear Power Committee of the Japanese Government re-examined the costs and risks of nuclear power plant accidents. The idea presented at the Committee was an accident probability of once in 500 reactor years, based on the fact that three major accidents had occurred for 1500 reactor years in Japan. It would mean that, if 50 reactors were in operation as was the case in Japan before Fukushima accident, there would be one major accident in every 10 years.

To review the risks of nuclear accidents, it is necessary to take a more realistic viewpoint. At least, we believe that the number obtained from the Probability Risk Assessment should not be used as the probability of actual nuclear accidents, and it is problematic to use such a number when discussing the risk probability.

2. Comparison of number of fatalities

In the discussion of risk comparison between nuclear power generation and alternative power generation sources, the number of fatalities is frequently used, especially the number of fatalities attributed to air pollution from coal combustion in developing countries. The argument frequently claims that the number of fatalities from air pollution is much greater than those from nuclear power generation, so nuclear power is needed as an air pollution reduction measure. (Revkin, 2013)

---

† As of Jan. 31, 2014, 1 Japanese yen is approximately 0.975 US cents.

In general, the calculation of air pollution fatalities refers to the works of Pope et al. (2002) and others, where the relevance between air pollution materials, such as $PM_{2.5}$ (particulate materials), and early deaths was discussed. In this particular study, Pope et al. used the statistical data available in the US to indicate a relative rise in fatality, mainly from cardio-pulmonary failures and lung cancers, associated with the increase in $PM_{2.5}$. The "projected increase in fatalities" was calculated by multiplying the relative fatality rise ratio with a certain number of population. Although there is no doubt that air pollution causes severe health problems, we feel that it is inappropriate to make simple and direct comparison of the damage from air pollution materials with damage from radioactive materials. This is because the processes of symptom onsets and fatalities differ considerably.

In the case of Fukushima, no direct fatality from exposure to radioactive materials has been reported up to now. The reason is not because a nuclear accident and exposure to radioactive materials are "safe", but because many people, hundreds of thousands of people in fact, were evacuated from the contaminated area relatively early on. Still, the exposure to radioactive materials such as iodine 131 did occur to a certain degree, and its long term effects have yet to be determined.

A more serious problem is the "indirect" fatalities of nuclear accidents. At the time of the Great Eastern Japan Earthquake and Tsunami, most of the disaster stricken areas of Tohoku (North-Eastern) region of Japan received immediate rescue and relief efforts from citizens groups, Japan's Self-Defense Forces and US forces. However, for the Fukushima coastal region, no-one, not even Self-Defense Forces, could enter the area for fear of exposure to radioactive materials, and the victims were left in the area for a long period of time. This resulted in so-called indirect fatalities, people who died due to difficult and long-term evacuation, or those who committed suicide, lamenting the radioactive pollution of their farm lands and farm animals and who had lost hope to ever rebuild their lives. These are considered as fatalities related to the nuclear accident, and their numbers have risen to 1459 as of September 2013, according to the Fukushima Prefectural Office (Fukushima Minpo, September 6, 2013). Though they are considered indirect deaths, they would have not died if there had been no nuclear accident.

The number of evacuees due to Fukushima nuclear accident is about 159,000 people as of November 2013. (Reconstruction Agency, 2013) Moreover, there are many places not only in Fukushima Prefecture, but also in other North-Eastern and Kanto regions of Japan where high concentration of radioactive materials have been detected. Many residents in these areas are forced to evacuate for a long time. In other words, there are very many people who have lost their home-towns, jobs, livelihoods, and homes because of the nuclear accident. A number of women left their hometowns to give birth, and some even decided not to go birth for fear of fetal exposure to radiation. As a result, the population and the number of births have declined in many areas after the Fukushima accident. For example, Koriyama City in Fukushima had a population of about 340,000 in 2010, but saw a 34% decline in births in January 2013, compared to January 2011 (Koriyama City, 2013).

In the case of nuclear accidents, tens of thousands of people can be forced to evacuate, depending on the scale of the accident, destroying the communities, and peoples' lives, and even resulting in losing lives that may have been born. This is the range of damage that occurs in the case of nuclear accidents. The risks of this happening really are enormous. Considering these factors, we believe that it is meaningless to try to make a simple comparison of these nuclear risks compared to the risks of air pollution and others based on a projected increase in fatalities due to disease.

3. Cost of nuclear power generation

The background of the argument on the need for nuclear power generation as a climate change measure includes the presumption that the cost of nuclear power generation is relatively lower than the costs of alternative sources. Yet, there are many doubts to such a presumption.

In discussions of the cost of nuclear power generation, figures published by the Japanese Government (5.9 yen/kWh: estimate made by the Japanese government in 2004) used to invite criticism for being too low, even before the Fukushima accident. This was because the published figure for power generation cost was calculated for an ideal model plant, and did not involve policy costs, such as research and development, or allocation measures (see Oshima, 2011). In actual fact, such costs were borne by the people of Japan in the form of taxation.

In addition, manufacturers are exempt from liability in Japan, as in the case of the US, on the basis that any responsibility of nuclear accidents would be aggregated to nuclear power entities (power generation companies). This meant that, even if a manufacturer of components for power plants delivered defective materials and these caused a nuclear accident, the manufacturer would not be held liable. If the manufacturers are liable for their products, then they may averse such work or product deliveries, or raise the costs of such products further.

After the Fukushima accident, the Japanese Government recalculated the power generation costs to incorporate social costs, such as policy costs and accident costs (costs for accident settlement, compensation, and area reconstruction), and came up with the number of 8.9 yen per kWh or more for nuclear power (provided that the cost would increase if accident costs were to rise in the future, and accident costs are in fact on the increase since the time of recalculation), 9.5 yen/kWh for coal power, 10.7 yen/kWh for LNG power, 9.9 to 17.3 yen/kWh for wind (on land), and 33.4 to 38.3 yen/kWh for solar (residential) as of 2010 (Energy and Environment Council, 2011). However, the figures for nuclear power generation costs did not include sufficient back-end costs of nuclear waste storage, decommissioning costs of failed reactors, and especially indemnification insurance. If these costs were included, the cost would no doubt exceed 100 yen/kWh, as indicated in some studies (Mikami, 2013). Moreover, although the cost of wind power and the cost of solar power are still relatively high in Japan at this moment, the international prices for the power generation by renewables are decreasing rapidly. For

example, according to the latest report on renewable energy, the cost of wind power (on land) is 5 to 16 cent/kWh for OECD countries, 4 to 16 cent/kWh for non-OECD countries. In case of solar power (residential), 20 to 46 cent/kWh for OECD countries, 28 to 55 cent/kWh for non-OECD countries and 16 to 38 cent/kWh for Europe. In case of ground-mounted utility-scale solar power, 12 to 38 cent/kWh for OECD countries, 9 to 40 cent/kWh for non-OECD countries and 14 to 34 cent/kWh for Europe (Renewable Energy policy Network for the 21st Century, 2013).

In other words, the cost of nuclear power generation seems to be lower than other energy sources simply because such cost does not include external costs, which are quite significant. In terms of not reflecting the true cost, operating a nuclear power plant is like driving a car without automobile liability insurance and its relatively high cost competitiveness is decreasing rapidly.

4. Worst-case scenario - one that Japan was able to avoid

Let us discuss here what actually happened in Japan. At the time of the accident at Fukushima No. 1 Nuclear Plant, an emergency response crew was based in the Important Quake-Proof Building at the site of the plant. This Important Quake-Proof Building was the only building within the plant site that had been designed to be earthquake-proof, and was thus able to avoid destruction from the quake. If it were not for this building, all the control and communication functions of the nuclear reactors would have been destroyed and lost, and it is highly likely that the reactors would have become totally uncontrollable.

Actually, this Important Quake-Proof Building was built because of the experiences of another earthquake in 2007 that struck Niigata Prefecture where another gigantic nuclear power plant is located. This kind of quake-proof building was built and began to be used from January 2010 at a nuclear power plant in Niigata Prefecture and from July 2010, at Fukushima No. 1 and No. 2 nuclear power plants (TEPCO 2010). If the mega-quake of March 11 had happened a mere nine months earlier, there would have been no Important Quake-Proof Building at Fukushima No. 1 Plant, and thus absolutely no way of controlling the nuclear reactors, which would have resulted in the immediate evacuation of many TEPCO personnel and other people at the site. Moreover, if the earthquake had happened not in the middle of a weekday afternoon, but during the holidays or at nighttime with fewer personnel on site, then controlling the nuclear reactors would have likely have faced extreme difficulties.

According to the documents dated March 25, 2011, belonging to Mr. Shunsuke Kondo, who was chair of the Nuclear Committee at the time, if the above situation had taken place, an even greater hydrogen explosion would have occurred, releasing a considerable amount of radioactive material from the No. 1 plant, thus forcing all workers to evacuate. Then, an even greater amount of radioactive material would have been released into the air from reactors No. 2 and 3 as well as from the fuel rod pool at No. 4 unit, necessitating the evacuation of all people living in 250 km radius. This would have

necessitated the evacuation of about 30 million people in the Tokyo megalopolis area. These documents were shown to only a limited number of people in the Japanese Government at the time of the accident, and the information was disclosed to the public much later, in the autumn of 2011.

If the earthquake had happened several months earlier, or even several hours later or earlier, then it would have been impossible to cool the melt-down core or fuel rods, and several tens of millions of people including those in Tokyo might have been asked to evacuate their areas. In the sense that we were able to avoid the case of the eastern half of Japan being "destroyed", the Fukushima No. 1 Plant accident could be described as a case of "consolation in the midst of calamity."

We also need to point out here the serious concern of terrorist attack on nuclear power plants. The Fukushima No. 1 Plant accident has demonstrated to the world how easy it is to cause a melt-down of a nuclear reactor by destroying its cooling systems, which can be done by causing electric power outage through an attack on the power grid using ordinary weapons. At present, there are hundreds of power transmission towers that could become the target of terrorist attacks with explosives. If several of these towers are destroyed by explosives, the nightmare of the Fukushima may revisit Japan.

5. Introduction of nuclear power as a set with coal-fired power generation

The theory of introducing nuclear power generation to reduce the number of coal thermal power plants seems to be too naïve a thought, in the political sense. In reality, nuclear power plants and coal thermal power plants were built and introduced in Japan simultaneously. For us, nuclear power and coal thermal power have been considered as a set, with coal thermal power acting as a back-up system in case of reduced operations at nuclear power plants. Consequently, Japan has consistently increased the number of coal thermal power plants, while promoting nuclear power generation, resulting in the eventual increase in CO_2 emissions.

The most important reason for this is the fact that stakeholders promoting nuclear power plants are the same as those promoting coal thermal power plants, i.e., economic bureaucrats, power generation companies, major heavy equipment manufacturers, and energy intensive industries. As they are in a mutually beneficial relationship, they share strong economic incentives to build a massive centralized power generation system and to maximize their fixed assets and electricity sales. Therefore, these stakeholders are inclined to be less enthusiastic to introduce energy-saving measures and renewable energy. In Japan, the Government and other stakeholders intentionally advocated for a trade-off relationship between nuclear power generation and climate change measures. Climate change measures are "used" to promote nuclear power generation. Many Japanese people have eventually accepted such an idea.

The conclusion in Japan is that, in order to reduce the number of coal thermal power plants, it is essential to reform the structure of industry and interests through denuclearization. Moreover, it is our

belief that such events and situations are not things limited to Japan, but will happen in any country of similar industrial structure and at a similar stage of economic development.

6. Role of new types of nuclear reactors

You may share the view that safer and newer types of nuclear reactors may not pose such problems. However, the number of third-generation nuclear reactors equipped with "passive safety systems," which have allegedly higher safety standards, is only 20% or less among the 76 nuclear reactors in construction around the world as of January 2013 (Japan Atomic Industry Forum, 2013), with the vast majority of the remaining reactors designed for second generation technology (Garthwaite, 2011). Most nuclear power reactors in operation are built with basic technologies established 30 to 40 years ago. Meanwhile the commercialization of fourth generation reactors, which is said to be safer, still has a very long way to go.

If you recommend the construction of new, safer nuclear power units, we believe you should advocate the shutting-down of existing, more dangerous nuclear power reactors. At the same time, it will be necessary to advocate a ban on exporting old-style nuclear technology to developing countries, even though Japan and other countries are promoting such exports at present.

Moreover, if we continue to see the current situation of exempting manufacturers from product liability and of limiting the liability of nuclear power entities, while private insurance companies continue to refuse damage insurance, then there will be no basis for the theoretical presumption of a "new and safer nuclear power plant." If you wish to promote safer nuclear power plants, we believe you need to argue for the revision of these systems.

No matter how safe a nuclear reactor is, the problem of nuclear waste is unavoidable. To ask future generations to manage such waste will likely present ethical problems, similar to the case of asking future generation to bear the burden of climate change measures.

Nevertheless, the introduction of safer nuclear power generation systems requires a much longer time span. It is unrealistic, therefore, to assume that nuclear power generation can be a measure for greenhouse gas emissions reduction in the immediate future, to achieve the two degrees C target.

7. Potentials of achieving the two degrees C target without nuclear power

Several studies have been conducted in the past to determine whether this ambitious climate change target is achievable without any reliance on nuclear power. Edenhofer et al. (2010) compared low-carbon scenarios using five different energy-economy models, and identified that the additional costs needed to stop nuclear investment in 2000 would be only around 0.7% of GDP in 2100. Recently other researchers have conducted studies in consideration of the denuclearization movement after the Fukushima accident. Bauer et al. (2012), for example, state that the reductions in greenhouse gas

emissions required to limit global average temperature rise to two degrees C from the pre-industrial era would be achievable for the additional cost of less than 0.1% of GDP by 2020, and less than 0.2% by 2050 without nuclear power. Duscha et al. (2013) state that denuclearization would increase global greenhouse gas emissions by 2% in 2020, but that developed countries would be able to achieve their share of the two degrees C target at an additional cost of 0.1% GDP. The same Duscha et al. (2013) reviewed other existing research, and concluded that most existing studies also indicated that ambitious greenhouse gas emissions reductions could be achieved at the additional cost of 1% GDP globally without nuclear power generation. Moreover, these studies did not incorporate the benefits of damage reduction by climate change measures. Incorporating such benefits, climate change measures will certainly increase their economic rationale.

Some may criticize these calculations as the mere result of energy and economic model calculations, but there are several facts supporting such results, including the rapid decline of LNG prices and cost reductions of introducing renewable energy, which have been greater than expected. Moreover, many countries have already demonstrated how policy instruments such as feed-in tariffs would help accelerate the dissemination of renewable energy.

Whether it is the selection of climate change measures or energy mix options, the biggest issues are economic costs, timings, and the people's willingness to pay. As we discussed above, if we can eliminate the barrier of vested interests, then it is technologically possible and economically feasible to achieve two degrees C target without relying on nuclear power or fossil fuels. Furthermore, the introduction of renewable energy and energy saving measures is the most preferable option, not only because of its significance in mitigating climate change, but also in terms of energy security and creation of new industries and new jobs. If we do not rely on nuclear power generation, it will certainly reduce the risks of plutonium proliferation and its conversion into nuclear weapons. This will further reduce the costs of radioactive waste management, thereby reducing burden on future generations.

8. Conclusion: Policy that does not rely on "Russian roulette"

We feel it is shameful that the international community as a whole has failed to act on the immediate problem of climate change, despite the growing awareness of its severity and seriousness. At first glance, nuclear power generation seems to be an important climate change measure, but when analyzed in detail, nuclear power can pose problems in terms of its economic rationale and ethical standards whether taken as a climate change measure or as an energy source.

In fact, promoting nuclear power may result in various adverse effects in addition to the acceleration of more reliance on coal thermal power as described above. At the beginning of this letter, we talked about climate change skeptics in Japan. Many of these people have been playing very important role in the anti-nuclear movement in Japan for a long period of time. They rallied against the

Japanese Government's rhetoric of "nuclear power generation is needed as a climate change measure" and so they are averse to the idea of anthropogenic climate change as well.

As the country that experienced the Fukushima nuclear accident, Japan may be unique in that it that lacks governance capability in various aspects. However, it is still one of the most economically developed countries in the world with a comparatively democratic political system. Japan is a nation that used to take pride in having "the world's highest level of safety" throughout its 40 odd years of operating nuclear power plants. On the other hand, many of the countries now wishing to build nuclear power plants anew are not economically rich, and frequently are under non-democratic regimes. Considering the risks and costs of building new nuclear power plants in such countries, it is questionable, and even fearful, that the international community is about to allow the promotion of nuclear power generation as a climate change measure. It is our sincerest hope that the international community fully realizes the severity of Japan's experience of the March 11 nuclear disaster, and reconsiders it stance on climate change measures and an energy mix that do not rely on the "Russian roulette" that is nuclear power generation.

References

Bauer, N., Brecha, R. J., & Luderer, G., 2012. "Economics of nuclear power and climate change mitigation policies", *Proceedings of the National Academy of Sciences of the United States of America*, 109, 16805–16810. doi:10.1073.pnas.1201264109.

Caldeira, K., Emanuel, K., Hansen, J., Wigley, T., 2013. "To those influencing environmental policy but opposed to nuclear power". https://plus.google.com/104173268819779064135/posts/Vs6Csiv1xYr

Duscha V., Schumacher K., Schleich J. & Buisson P., 2013. "Costs of meeting international climate targets without nuclear power", *Climate Policy*, DOI:10.1080/14693062.2014.852018

Energy and Environment Council, Committee to review costs and others, 2011, "Report of the Committee to Review Costs and Others", Dec. 19, 2011. (in Japanese) http://www.enecho.meti.go.jp/info/committee/kihonmondai/8th/8-3.pdf

Edenhofer, O., Knopf, B., Barker, T., Baumstark, L., Bellevrat, E., Chateau, B., van Vuuren, D. P., 2010. "The economics of low stabilization: Model comparison of mitigation strategies and costs", *The Energy Journal*, 31(Special Issue 1), 11–48.

Garthwaite, J., 2011, "Would a New Nuclear Plant Fare Better than Fukushima?", *National Geographic News*, March 23, 2011. http://news.nationalgeographic.com/news/energy/2011/03/110323-fukushima-japan-new-nuclear-plant-design/ http://www.nationalgeographic.co.jp/news/news_article.php?file_id=20110324001 (in Japanese)

Japan Reconstruction Agency, 2013, "Report on the current situation of reconstruction from the Greater Eastern Japan Quake". http://www.reconstruction.go.jp/topics/20121122_kokkaihoukoku-gaiyoh.pdf

Koriyama City, 2013, Koriyama City Office web site, "Current residents of Koriyama City, as of February 1, 2013. (In Japanese) http://www.city.koriyama.fukushima.jp/pcp_portal/PortalServlet?DISPLAY_ID=DIRECT&NEXT_DISPLAY_ID=U000004&CONTENTS_ID=11987

Mikami, Hajime, 2012, "However calculated, nuclear power is expensive". (in Japanese) http://pikagen.hamazo.tv/e4452920.html

Japan Atomic Industry Forum, 2013, "World trend in the development of nuclear power generation", Policy and Communication Department, July 2013. (in Japanese) http://www.jaif.or.jp/ja/joho/press-kit_world_npp.pdf

Nordhaus, William D., 1997. “The Swedish nuclear dilemma : energy and the environment” Washington, D.C. : Resources for the Future, 1997. (Translation into Japanese, published by Denryoku Shinpo Sha (currently Energy Forum), 1998)

Oshima, Kenichi, 2011, “Cost of Nuclear Power Generation”, Iwanami Shoten. (in Japanese)

Pope III C. Arden; Richard T. Burnett; Michael J. Thun; Eugenia E. Calle; Daniel Krewski; Kazuhiko Ito; George D. Thurston, 2012. “Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution”, *JAMA*, March 6, 2012 - Vol 287, No. 9.

Renewable Energy policy Network for the 21st Century, 2013. “Renewables 2013: Global Status Report”. http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf

Revkin, Andrew, 2013. “To Those Influencing Environmental Policy But Opposed to Nuclear Power”, November 3, 2013, *New York Times*. http://dotearth.blogs.nytimes.com/2013/11/03/to-those-influencing-environmental-policy-but-opposed-to-nuclear-power/?_r=0

TEPCO, 2010. “Safety measures of nuclear power plants”. (in Japanese)