FUKUSHIMA FOR YOU AND ME? CONTENDING WITH THE SOCIAL DISRUPTION CAUSED BY A NUCLEAR ACCIDENT

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Abstract

Social disruption ranks high among consequences of a nuclear accident yet appears not fully understood.TMI, Chernobyl and more recently Fukushima have demonstrated that the severity of a nuclear accident depends on both its technical and social characteristics. The proximity principle is generally applied to frame disasters, but in the case of nuclear energy, the accident's impact extends far beyond the geographic perimeter defined by technological failures and radiological consequences upon health and environment. While the latter are carefully studied, there remains the task of better grasping the nature of the consequences' full impact upon society. We propose a conceptual framework to support better understanding of the underlying mechanisms of social disruption experienced at both the local and global levels. General risk concepts such as stigmatization, risk acceptability, and social amplification of risk, can aid at a first degree of analysis. In addition, we identify characteristics specific to nuclear accidents, such as ″collapse of the safety myth″ and ″removal of distance″ which appear common to Chernobyl and Fukushima. The collapse of the safety myth adds to the shock of the accident which was not supposed to happen. The removal of various distances represents as well a most disruptive experience and generates understandable resistance. Conversely, this effect could enhance a sense of solidarity among countries and among social groups. Integrated into nuclear research, education, and training, this conceptual framework could constitute a contribution to community resilience.

Keywords: *Nuclear accident, Proximity, Social disruption, Safety myth, Removal of distance*

Introduction: nuclear power and the proximity principle

"Whenever there is a lot of energy in one place and a lot of people in the same place, there is a potential for disaster". This rather straightforward assertion made by physics Nobel laureate Eugene Wigner (1902-1995) and recently reported [1] underlines the principle of proximity between energy and populations related to the risk of disaster. This proximity principle can be associated to a variety of disasters and applies as well to the case of a nuclear accident: a nuclear reactor concentrates high levels of energy, and an immediate set of potential victims is to be found first among operators, rescue personnel, and the neighbouring population.

But severe nuclear accidents also give a new meaning to “proximity”. Airborne radiation is a potential vector of exposure for populations far from the source of release; according to meteorological conditions, radioactive material can travel across continents. In this way, different implicit definitions of "proximity" are observed in the literature. In the aftermath of Fukushima, Butler [2] for instance analysed world population exposure to accidental release from the 211 NPP sites across the planet. Using concentric zones extending up to 1,200 kilometres, he concludes that distance does not offer “much of a protection” for most of the world's population. However, a 30-kilometer radius was considered pertinent for the evacuation or sheltering of 88,000 persons living in the vicinity of the Fukushima Daiichi plant. In the study of population around French NPPs to consider evacuation planning in case of a severe accident, analyses are restricted to zones of 30, 75 and 150 km [3]. On that basis, one may ask to which risks are Butler’s populations actually exposed in that 1,200 km radius.

Along with these issues of population and environmental radiation exposure associated with geographical distance and meteorology, other variables such as economic costs enter into play. The cost estimates based upon accident scenarios involving either controlled or massive releases in France find the highest share (40%) to be attributable to "Image costs" [4]. Analysed from the point of view of France being impacted, the authors include in their definition of image costs the reductions of exports (agricultural, foodstuffs, and others) and of tourism activity. Needless to say, these exports would be of perfectly clean products, and tourism would be in non contaminated areas. In other words, such levels of impact which appear very important in terms of economic costs, do not relate directly to radiation contamination nor exposure: thus, a nuclear accident's impact cannot be restricted to the definition provided by the proximity factor nor to actual exposure to radiation.

It had already been established that the situation of a nuclear accident can trigger health consequences upon the local population, even in the absence of radiation release.

In the TMI case, substantial release occurred within the containment building but immediate radiological consequences for the environment were negligible. However, chronic stress-related sympathetic arousal was measured at higher levels in TMI area when compared to a control group [5]. In addition to health and economic impacts, TMI, Chernobyl and Fukushima cases showed that further indirect consequences are to be found in decision making, sometimes at a national policy level. The example of Germany's decision to finally consolidate its phase out from nuclear in the aftermath of Fukushima is emblematic. We questioned above the relevance of the 1,200 km radius used by Butler to estimate potentially exposed populations. Nonetheless, it must be acknowledged that concerns of populations actually appeared at a distance even further away, such as in France (about 10,000 km from Japan) where the "Fukushima cloud" was expected and monitored (while the radiation level in France from Fukushima was generally agreed to be negligible, the daily newspaper *Le Parisien*, 23 March 2011, was attentive to a potential for controversy: an NGO considered that measurements performed by the French Institute for Radiological Protection and Nuclear Safety (IRSN) underestimated the radiation level.). As it happens, a nuclear accident attracts attention worldwide and is among the most widely media covered events. Global and continuous exposure to the news of a nuclear accident can make it difficult for populations to differentiate risk and concern. High levels of concern are neither always indicative nor predictive of the existence of an actual threat, yet public concern is a social fact and ought to be considered as such among risk governance factors [6].

Nuclear accidents can be first described using the proximity factor as it generally applies to disasters. However, it is clear that the impact of a nuclear accident extends largely beyond what appears to be the usual perimeter of other technological accidents. Additional dimensions need to be taken into account: concern occurs quite far away from the source, health consequences are mentioned even in the absence of actual radiation, and policy can be durably affected. Technical issues of a severe accident such as meltdown, containment, or radiation release and protection, are of utmost importance and deserve research efforts so as to improve safety. The fact remains that population' responses and concerns enter into play as major issues as well. While there is little doubt about this evidence based fact, it does not necessarily mean that the mechanisms which come into play between the accident and the public are well known. The full extent of indirect consequences and their social and psychological dimensions ought to be further studied, with the goal of avoiding biases of attenuating or amplifying these aspects of a severe nuclear accident. As pointed out by ASME [4], the focus must remain on reactor safety and protection of public health from radiological releases, yet should address as well the social and economic disruptions which appear to be among the major consequences of severe nuclear accidents. In sum, the question of the *nature* and *extent* of impact of a nuclear accident arises as a central research issue in spite of the extensive reporting already accomplished.

The goal of this paper is thus to analyse the psychological and social dimensions associated to a nuclear accident, in the perspective of better understanding the caused social disruption. In the search for explanatory factors, we proceed by looking at latent background factors revealed in societal responses after Fukushima. We pursue with a set of concepts relating to general attitudes and social perceptions of nuclear energy. Then we identify characteristics specific to severe nuclear accidents, such as the concepts of ″collapse of the safety myth″ and ″emoval of distance″ which appear common to Chernobyl and Fukushima.

Nuclear and society before and after Fukushima

While psychometric surveys and policy studies can provide upfront data, deeper background factors become apparent when we compare the societal responses to Fukushima with the previous state of affairs regarding nuclear power. Fukushima occurred at a time when nuclear power had regained interest, particularly as an option in the energy production mix with the goal of improving CO_2 sobriety. However, reactions worldwide following Fukushima rapidly challenged this perspective in several countries, with decisions such as postponing new projects or even complete phasing out as in the case of Germany. Globally, the International Energy Agency (IEA) had to revise its previous figures: while the number of plants in operation had been foreseen as doubling in the coming years, after the Fukushima accident this prediction of significant increase was reduced by half. How could a single event be at the source of such radical changes?

In the second half of the 20th century, nuclear energy presented benefits for electricity production, while this technology was characterized as a low probability-high consequence (LPHC) risk. This characteristic raised issues of risk assessment and management among experts, as well as issues of public understanding and communication. Public concerns for the consequence side of the LPHC equation led to early mobilisation against nuclear programs and national differences in social acceptability became apparent [7]. The TMI accident in 1979, and moreover the Chernobyl accident in 1986, negatively impacted public perceptions, and decisions at government levels brought about cut downs of nuclear programs. But the need to produce increased quantities of electricity, together with the climate change threats and 3rd-generation reactors development, brought in early 2000's an ending of what was sometimes referred to as a ″nuclear energy winter″. On the whole, since 2005, European countries showed an increase in acceptance of nuclear energy [8]. Along with the classification of nuclear as ″CO_2 sober″ within the climate change debate, another explanation for this relative acceptance is the experience of nuclear production in many European countries. Populations get accustomed to debates and become better informed, while nuclear is considered to be more and more ordinary.

In favour of nuclear energy's case, although each point is typically subject to controversy, we can find: safety's positive results, low environmental impact, and cost of electricity.

The level of fatalities per output caused by nuclear operations is lower than that of other means of energy production or other industrial activities [9]. On the other hand, a terrorist risk is raised. In addition, governance methods still have to be developed for waste management to treat equitable risks and benefits through generations and countries. Cost issues are debated so as to include properly accidents and dismantling, as well as uncertainty for the financing of new projects. Post-Fukushima measures to improve safety and population protection bring additional costs to nuclear production of electricity.

Decisions about nuclear energy seem dependent upon technical factors and upon social factors. For instance, the German decision to phase out contrasts with other European countries' decision (e.g. U.K.), which is a situation difficult to explain should technical factors be predominant in decision making. Other such factors appear in a study in the context of Switzerland before and after Fukushima [10]. The accident had a negative impact upon the acceptance of nuclear power as well as its trust, yet determinants of risk perception such as benefits remained unchanged. However, within the global social controversy about nuclear risks, an accident such as Fukushima likely brings support to already existing unfavourable perceptions of nuclear energy (even if these do not translate into State level policy decision). Lasting memories from past accidents, particularly Chernobyl, likely remain in the background (although this is arguable at some degree if we consider the Japanese context, see Section 4), as well as does the issue of nuclear waste management with its far reaching time dimension.

On this basis, one can easily infer a rather high degree of sensitivity when the matter comes to nuclear risk communication and the public, both in ordinary times and particularly during accidental situations. Transparency has become a major tool in societal risk governance in the past decade and notably in the nuclear safety field [11]. Interestingly the tension between full disclosure and sensitivity to information impact was explicitly considered by WHO experts in 1958 during the very early years of nuclear energy development [12]:

Although the case in favour of concealing nothing from the public appears to be unanswerable, there is, nevertheless, a duty to study the psychological principles of the presentation of anxiety-raising information in relation to the capacity of the public to endure it.

Almost sixty years later, this statement is quite relevant and challenging for risk communication. In the next section, we present the main concepts relating to social perceptions of nuclear energy. We note in passing that these concepts were developed, if we keep in mind the above statement, in a global governance context in which there was more drive towards opening up information than attention to its effects.

Social perceptions of nuclear power

Early on, technology appears to be associated with public concern through the occurring controversies. Based upon the 1980's technological developments controversies arose along with public reactions to nuclear energy. To further investigate divergence of perceptions among the public, experts, and policy makers, several notions which relate directly to nuclear energy among other risk fields, have been identified, e.g. : the dimensions of risk perception, trust and cross-cultural differences, stigma, social amplification of risk, and risk governance.

Dimensions of risk perception

Early research on risk perception [13] maps a set of 81 hazards on two factors. Factor 1 ("Dread risk") results from a combination of characteristics entitled such as: Uncontrollable, Dread, Global Catastrophic, Fatal Consequences, High Risk to Future Generations and Factor 2 ("Unknown risks") results from combinations of characteristics such as Not Observable, Unknown to Those Exposed, Effects Delayed. Among the 81 hazards distributed between these factors and their opposite, "Nuclear Reactors Accidents" appears located in the quadrant form by the two factors “Dread” and “New”, close to the "Nuclear weapons fallout" factor. This string of research also revealed that risks are often better accepted when individuals engage voluntarily in activities which they consider to be under their control and/or resulting from a decision they made (e.g. skiing, airplane transportation, smoking) vs. activities which do not appear to result from their choice (e.g. nuclear power plant, oil refinery, paper mill). Various biases affect people’s judgments or decisions. Equally negative outcomes can be evaluated differently depending upon their cause, e.g. nature vs. human-caused hazards (the latter being more negatively evaluated), and this affect heuristic presents a challenge for acceptance of risk-benefits analysis [14]. The studies presented in the following have identified additional dimensions that help understand how risk perceptions are structured.

Trust and cross-cultural differences

When comparing the ratings of various hazards and general attitudes towards risk as measured in France and the US with national samples of the population (n= 3,000), it appears that the perception of nuclear risk, as well as most other risks, is very much similar. However, significant differences lie in the strong contrast between the high level of trust witnessed in France for nuclear operators and regulators, as well as in experts, compared to the lower level of trust in the U.S. [7]

- *We can trust the experts and engineers who build, operate, and regulate nuclear power plants.*

  France: 66% US: 43%

- *Decisions concerning risks for health should be left to the experts.*

  France: 68% US: 23%

These results show that the data about risk perception alone is not enough to understand the relation between a social context and nuclear power.

Additional knowledge, such as provided by general attitudes about trust and the role of experts, must be accessed as well.

Nuclear stigma

Nuclear stigma [15] is a concept which helps to understand why the "image costs," e.g. those linked to exports and tourism losses as mentioned above in the introduction, appear to make the highest share among the economic assessment of a possible nuclear accident. Nuclear stigma refers to the aversion for places, or objects, which are rejected because of their association with the nuclear technology and danger of radiation. In addition, such danger being strongly rejected, whoever appears responsible for it is perceived as having failed in terms of public safety, and can therefore be associated with illegal, antisocial or immoral attitudes (thus leading to the inclusion of ethics among governance issues). Typically, these elements contribute to shape the meaning of risk in a given context and have to be looked at carefully in relationship with stakeholders, e.g. when considering the siting of a new installation.

Social amplification of risk

The social amplification of risk framework (SARF) is an integrative model which puts in perspective a whole set of mechanisms tending to form the social experience of risk, ranging from and including: information processes, institutions, social interactions, and individual behaviour. Importantly, this phenomenon impacts the level of risk consequences by extending these in case of amplification (and by moderating them in case of social risk attenuation). Risk issues can be amplified at various stages of risk information circulation, with specific "stations" such as the media, institutions, scientists, social networks [16]. This framework posits clearly that the consequences go beyond the scope generally used in risk assessment, i.e. fatalities and damages, to include the expression of social concerns of which "ripples" can extend to various issues, and over time generate economic and political consequences. The German policy decision to phase out after the Fukushima accident can partly be explained through this social amplification perspective.

Risk governance

Put simply, risk governance concepts and methods are about involving stakeholders in the risk analysis process of assessing, managing, and communicating risks. This appears necessary for risks characterized by uncertainty or ambiguity. The standard risk analysis process is thus modified, e.g. by questioning the definition of issues being assessed, and by introducing concern assessment [6]. In practice, remains as well the problematic relation between risk and concern, as they cannot be totally separated nor simply confounded.

Additional factors can influence risk perceptions and social attitudes regarding nuclear. And while these background levels of analysis are all useful in delineating the social contours of nuclear power, it appears necessary to go deeper in order to grasp the specificities of nuclear accidents, notably in terms of the rupture of the safety myth, and the removal of distances.

The rupture of the safety myth

As analyzed in the policy response study of the Chernobyl accident [17, 18] nuclear energy was developed within a tacit social contract among all actors involved, including the public, to fulfil both a societal wish and a safety goal which we can subsume as follows: *"Nuclear accidents are not supposed to happen"*. The unexpected nature of nuclear accidents is underlined as well more recently, leading to what is defined as an institutional blindness about nuclear meltdowns [19]. How we came to this situation deserves closer attention.

NPP's are ranked among high reliability organizations (HROs) which are designed and operated to aim at error free performance. As technology characterized by a LPHC type of risk, the "worst case" accidents were projected in the very far future of reactor-years operations. The collusive dimension of this tacit contract is important to note. In a sense, this contract results from the pressure from all sides: as the level for social acceptance of nuclear risks is low, probabilistic risk assessment (PRA) had to reflect this. One may extend this understanding to the analysis of the Fukushima disaster, as did the independent investigation commission which handed a report to the Japanese parliament in July 2012. The Kurokawa report explains the disaster in terms of "regulatory capture," suggesting that the relationship between the regulators and the regulated was much too close, enabling the industrial actors to subject the safety authority to undue pressure and influence. "The Fukushima nuclear power plant accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties; (...) They effectively betrayed the nation's right to be safe from nuclear accidents. Therefore, we conclude that the accident was clearly 'man-made' "[20].

The TMI and Chernobyl accidents had wide-reaching impacts, affecting populations, the environment, policy and technological developments. On a less visible level, they also represent the rupture of this very special socio-technical contract that carried the strength of the converging needs and wishes of all parties. This rupture added to the shock created by the accident. As it was not supposed to happen, psychological and social preparedness was not apt enough to take into account this most abnormal occurrence, and resources were lacking to face the reality of a nuclear disaster. Since then, some policy changes can be seen that aim to better deal with the pre-accidental information.

While technical improvements of reactors' reliability and operators' training were pursued, a different doctrine regarding public information appeared as well. An example of this new doctrine is provided with the public diffusion in France in 1990 of PRA data setting at 1% the probability of occurrence of an accident at level 5 on INES scale (comparable to TMI). More precisely, the accidental occurrence was assessed at 1% for the whole pool of reactors in France and over a 20 year period. This assessment has since then been revised to a lower level of risk. Operating incidents in NPPS are regularly reported and made public.

Another way to introduce the accident possibility into the realm of things which can happen has been to organize in many nuclear countries, post-accidental simulations and exercises.

The management of various everyday life issues, such as impact upon agricultural foodstuff and land contamination, are usual parts of these exercises which get populations involved. Environmental releases are simulated and radioprotection personnel are sent on the field. Media are invited as well to lay out their role during the exercise. All these factors contribute to the credibility of the simulated accident. In the French context, these exercises and related information are openly integrated into accident preparedness [21]. Such activities are undertaken with many similarities in several European countries in spite of different regulations. In addition, specific studies are undertaken and made public to analyse the populated areas around nuclear power plants, so as to better plan evacuation in case of an accident [3]. Still in line with putting the nuclear accident closer to real life conditions, the economic assessment of an accident based upon massive releases [4] takes into account a wide range of costs, e.g. upon tourism. While these studies were undertaken before Fukushima, the presentation of results after the accident attracted public attention. Although likely less known by the general public, severe accident research focuses on very explicit key safety issues for various types of reactors [22].

On the basis of all of the above activities and information tending to render credible the eventuality of an accident, one could have thought that the previous state of representations which we subsumed under the notion "Nuclear accidents are not supposed to happen", would have been replaced by the notion that "Nuclear accidents can happen." Actually, this is not quite the case. The notion of tacit contract itself is used as well in the aftermath of Fukushima by Higuchi [23 who insightfully considers that "if there is any tacit collusion that led to the Fukushima accident, it is the unwillingness of each individual to critically re-evaluate his or her own default stake in the use of nuclear power". Interestingly, the collusive dimension of the tacit contract appears motivated by the benefits provided by nuclear energy: "All Japanese people have successfully been turned into stakeholders by default: reactors provide strength to the state, profit to corporations, knowledge to scientists, wages to workers, and electricity to consumers." [23]. In a meeting on radioprotection issues following Fukushima, an analysis was presented criticizing the way safety of NPPs had been “mythicized” in the Japan context, to the point of dismissing pluralistic points of view, i.e. leading to rejecting the possibility of an accident [24]. Furthermore, a survey was conducted with the members of the Young Researcher’s Association of Japan Health Physics Society, representing universities as well as utilities. Respondents are experts born after 1977 and belonging to Universities (e.g., Meiji, Tokyo, Nagoya, Kyoto), Research institutes (e.g., JAEA, NIRS, AIST, CRIEPI), Utilities (e.g., Tokyo, Chubu, JNFL) and Manufactures (e.g., Fuji Electric, Chiyoda, VIC). The young Japanese experts expressed that they were: "Shocked by the nuclear accident, especially by the collapse of the safety myth"[25].

The survival of such a safety myth, allowing the shock created by its collapse, can thus appear like an unexpected repetition of what was analyzed after Chernobyl. Furthermore, it is important to note that this was a result of a survey conducted among young Japanese experts, better educated and informed about nuclear risks than the other social groups. This type of result shows that more research focusing on social representations could be developed within the nuclear milieu itself, with the aim to develop a higher degree of reflexivity. Apparently, the historical cases such as TMI, Chernobyl, and more recent nuclear incidents in Japan, had not impacted much the preparedness doctrine and the state of beliefs in Japan until the Fukushima occurrence. While the common notion that Chernobyl memories remain present in the public's mind might be true overall, such memories seem superseded by the strength of the collective beliefs involved in the tacit social contract as shown in the Japan context. It has to be noted that the information doctrine which integrates the accident possibility as part of preparedness, seems less implemented in Japan. Global standards for disaster response had been rejected by the Japanese nuclear regulator, for fear of undermining public trust [26].

In a sense, and even from the point of view of the young Japanese experts, the tacit contract about safety remained unbroken as if Chernobyl had not occurred. In this way it appears that Chernobyl de facto was not a relevant experience in the Japanese context. Evidence for the existence of this phenomenon in other contexts as well, or its eventual specificity to Japan, remains unverified. Another open research question concerns the various national strategies followed for accident preparedness and public information. A sharp contrast appears at that level between France and Japan. More generally, this is a strong indication that cultural differences between countries would make it difficult to define standards for a universal preparedness strategy.

The removal of distances

When the German electronic band Kraftwerk presented their concept album "Radio-Activity" with the song "*Radioactivity is in the air for you and me",* (1975, *Radio-Activity*. Phillips records, Dusseldorf, Germany, http://www.youtube.com/watch?v=hhBG1ilB3ao) they stated with artistic flair one major characteristic that would later be revealed by nuclear accidents: the ubiquitous impact as experienced by society along with the widely shared impression of closeness with radioactivity, as if the accident was here for each of us. Thus another set of phenomena specific to nuclear accidents had to be analysed in the aftermath of Chernobyl. It appeared that this accident could be characterized through the removal of several types of previously well established distances along with their protective function, opening the way to various impacts on society [18, 19].

Geographic and national distances

Chernobyl was noted for its "transnational" character, with radiation releases covering large areas and radioactive clouds going over borders, regardless of national considerations.

In response to this situation, different modes of managing the public information appeared from one country to another. A lasting controversy happened in France about

discrepancies of radiation levels measured on each side of the border with a neighbouring country. Beyond the anecdotic aspect, this controversy revealed how dismayed a population could become when a border ceased to be a protection, both real and symbolic, against an outside threat.

Political distances

Following the Chernobyl accident, the then IAEA Director, Hans Blix, insightfully stated in November 1986 that "Chernobyl showed that a serious accident anywhere has consequences for nuclear power everywhere." This statement underlined the interdependence of national contexts, although each nuclear program had been developed within the frame of sovereignty of each country. It became apparent that most governments had to re-evaluate nuclear power place and energy alternatives, not as a freely chosen option, but under the pressure of an outside event. Policy differences between nations (e.g. regarding independence of nuclear safety authorities, the management of public information, and accident preparedness) are revealed when an accident occurs and generate dissonance and incomprehension: *who and what is right?*

Social distances

Another established distance that was shaken is linked to the division of labour forces and the societal sharing of risk. Any type of energy production has human and social costs. The history of coal mining is a reminder of a high toll of deaths and casualties impacting miners, their families, and communities. But groups outside the miners' community were not directly concerned, and it is still the case nowadays as fatalities from coal mining remain high. With a nuclear accident, while its consequences first follow the proximity principle, impact extends as well to all social groups and even to other countries. Thus, the risk burden is not limited to the groups charged with energy production; the whole population gets involved. In a sense, the nuclear risk can be said to be more egalitarian than many others, but society might not be ready to appreciate this quality as it means to reconsider the established social distribution of risk.

Temporal distance

While the Chernobyl accident is moving away in the time perspective, some closeness remains as if the temporal distance had been removed. Lasting radiation in the surroundings of the accident's site leaves large areas unfit for populations to live. And in the French island of Corsica, a controversy about a medical expertise attributing cases of thyroid cancers to Chernobyl is presently ongoing, showing the lasting concerns triggered by a long past accident.

Personal distances

Last but not least, a nuclear accident put individuals in the situation of being confronted with a threat which cannot be stopped. The safety myth collapsed, national boundaries and social distances are trespassed, and another limit is attacked: that of the private distance between inside and outside. Fukushima, as was the case with Chernobyl, comes to your doorstep without knocking for an unsolicited encounter which cannot be declined. The experienced threat is both directly that of radiation for a small part of the population and, indirectly, a threat carried home to a very large population through the news of the accident.

The removal of all the above described distances represents a most disruptive experience widely associated to a nuclear accident and generates understandable resistance at both the psychological and social levels. Conversely, a positive response could be hypothesized: the removal of geographic, national, and political distances could increase a sense of solidarity among countries and among social groups.

Discussion and conclusions

Characteristics specific to a nuclear accident and leading to social disruption started to be acknowledged with TMI and were further analyzed with Chernobyl. With Fukushima, social disruption appears even more clearly to be at the forefront of the consequences caused by a nuclear accident. In this paper we presented the main mechanisms explaining this phenomenon, a necessary step aiming at defining possible ways to tackle this level of consequences among the others and, possibly, improve accident preparedness and populations resilience.

Nuclear accidents impacts are among the most widely reported and commented events of our contemporary world and the Fukushima occurrence made no exception. Yet, the effect of such a generalized exposure to information remains somehow in the shadow. For instance, it is somewhat difficult to understand how the Fukushima accident could have significantly impacted nuclear energy which had previously gained consideration as a safe option in the energy mix for a CO_2 sober society.

To better understand how a single event can have such a powerful impact upon society, we proceeded first by examining the proximity principle between energy and populations. This principle applies to the case of nuclear energy, but the consequences of a nuclear accident go well beyond what it envisions. Some explanation for the indirect consequences, i.e. not related to actual human or environmental exposure to radiations, is partly found in results from social science risk research. Nuclear risks appear associated with dread and concepts such as trust, stigma, and social amplification of risk provide further understanding. But these characteristics are not specific to the nuclear accident situation which includes additional complexity. Others elements needed to be investigated to encompass the wider aspects of the social disruption caused by a nuclear accident. From the Chernobyl experience, the existence of deeper factors was identified. The rupture of a tacit contract appears associated to the loss of the safety myth, with which all parties tacitly agreed. The removal of distances, such as those which exist to delimitate nations, politics, and social groups, is another phenomenon typical of the uniqueness of a nuclear accident.

On a comparative basis, several characteristics seem common to both Chernobyl and Fukushima: public concern and political decisions appear quite far away from the accident to confirm the removal of distances effect. Surprising is the finding of a survival of the safety myth, and the shock provoked by its loss in Japan. This belief appears to be deeply entrenched in spite of Chernobyl. The doctrine of information, accident simulation and preparedness, which tends clearly to put the accident's possibility into the realm of things, seems less developed in Japan.

These results raise several questions. The removal of distances effect appears established on the basis of both Chernobyl and Fukushima. As this effect would likely be common to any nuclear accident, representing a most disruptive experience and generating understandable resistance, it is worth examining how to cope with it. We hypothesized the possibility of a positive response: *the removal of distances could trigger a sense of solidarity among countries and among social groups*. It remains unclear at this point if an increase of solidarity occurred at the various levels where the distances are removed. A negative answer seems to come first: *reactions from most parts of the world to the cascading event of March 11, 2011 tended to disregard the earthquake which triggered the giant tsunami, and the associated fatalities and damage, to focus upon the meltdown at the nuclear reactors as a source of concern and stigmatization*. Conversely, high levels of solidarity were shown by state officials around the world and by nuclear organizations and experts who offered to help. Volunteers from civil society in Japan and elsewhere proposed their services. Furthermore, international agreement has been granted to Tokyo to host the 2020 Olympic Games, regardless of a string of problems at Fukushima some 145 miles away. Tokyo residents strongly backed the 2020 bid (while the 2016 bid lacked enthusiasm) and the decision from the International Olympic Committee (IOI), representing most nations, can be interpreted as an expression of solidarity and trust for the future. Other expressions and evidence of solidarity, at various levels of society in Japan and outside might exist and would deserve to be better reported and reinforced as a means to contend social disruption and strengthen community resilience. As it turns out, energy is the vector put forward by the proximity principle, but information is another vector which appears equally important in nuclear accidents: nearby populations are potentially exposed to radiation, a much larger set within the world's population is exposed to the worrying news of the accident. The solidarity conditions which would increase resilience at both the local and global levels of populations ought to be further studied.

In this context, risk communication appears as a major challenge, both at the early phase of a nuclear accident and later on [26]. Among the issues following Fukushima is the difficulty to generate and communicate reliable information on possible health risks associated to low dose exposure over time, as the estimated doses seem too small [27]. This reasoning based upon radiation epidemiology likely contrasts sharply with the representations and expectations of the public. Is it possible to make sense of such a gap? Social representations research has emphasized that an object's salience is not determined by physical distance but by its position in the "cognitive space" of a population that may be concerned or affected by this object [28]. The concept of socio-cognitive exposure, characterized by sustained exposure of populations to potentially worrying information, was recently explored to integrate this phenomenon into risk analysis [29]. Further research, such as the ongoing European research project EAGLE is needed to improve information and communication processes related to ionising radiation. EAGLE project (http://eagle.sckcen.be) is a 3 years Euratom FP7 "coordination action", launched under the work programme 2012 which will help identify and disseminate good practices in information and communication processes related to ionizing radiation.

While the impact is said to be everywhere, nonetheless a nuclear accident happens somewhere, triggering local responses themselves depending upon existing contextual variables. We saw that the strength of the safety myth had remained high in Japan among young experts. Further research ought to examine if it is the case in other social groups and countries as well, or if local conditions make this social contract more desirable within the Japanese context. What appears as the trust paradox deserves to be studied: on one hand trust seems needed for public acceptability of risk (and this is a renewed goal of the Japanese Atomic Energy Commission after Fukushima), on the other hand responses to the nuclear accident indicate that too high a level of trust had been invested into what became bitterly commented as a safety myth. Research seems needed to better understand the policy assumptions regarding trust, along with the doctrine about public involvement in accident preparedness. The question of standards common to all countries versus accommodation of local policy choices ought to be examined under that light.

Along with continuous technical improvements of reactor safety, nuclear systems have integrated human and organizational factors into conception and operations. For instance, the safety culture framework, first developed within the nuclear context is now used by all major industries. In short, nuclear presents a high degree of performance and competence at the technical level as well as at the human/organizational level. The matter is now to further the understanding and integration of constraints stemming from the larger social system, in particular to better contend with the disruption caused by an accident and improve community resilience and both the local and global levels. An international and multidisciplinary working group ought to focus upon this specific task.

Acknowledgements

An earlier version of this paper was presented at ERMSAR 2013, the 6th Conference on severe accident research (SARNET)`- Avignon (France), and benefited from discussions with participants. This revised version was partly funded by the EC - DG for Research: FP7 project EAGLE, grant agreement no: 604521. The views presented are the sole responsibility of the authors.

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