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2017

Ontario is not ready to face a large-scale nuclear accident

Analysis by ACRO
RAP170728(1)Ontario_EP&R

July 2017

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"It should be assumed that "all possible phenomena would occur". Moreover, it is necessary to recognize that there could be kinds of phenomena, which do not even be recognized as impossible phenomena, in other words, unthinkable phenomena can also occur. […] It is necessary to make full preparations based on the assumption that unthinkable phenomena might occur."

Prof. Yotaro Hatamura in *Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company*, [ICANPS2012].

"WHEN I was young, there seemed to be never a childbirth, or a burst appendix, or any other drastic physical event that did not occur simultaneously with a snowstorm. The roads would be closed…"

Alice Munro, *Dear Life,* Vintage books, London (2013)

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1. Introduction

1.1. International standards

Severe nuclear accident can happen anywhere with impacts across borders. According to the International Atomic Energy Agency (IAEA), *"an emergency at a nuclear power plant that involves damage to fuel in the reactor core or in a spent fuel pool can cause deaths, severe health effects and psychological effects, and can also have economic and sociological consequences affecting the public. […] In the most severe emergencies, [the] plume can possibly result in injuries and deaths within hours of a release for those located within about 2 to 5 km of the nuclear power plant if protective actions are not taken. These injuries would be the result of inhalation of, and from external exposure due to, the radioactive material in the plume, or from exposure to radiation emitted by radioactive material that is deposited on the ground. […] Further away from the nuclear power plant, within about 15 to 30 km, inhalation of the radioactive material in the plume could result in an increase in the cancer rates"* [IAEA2013].

To avoid such accidents or mitigate its consequences, nuclear safety is based on *"defence in depth"* with five independent levels of protection. The objective of the last level is the *"mitigation of radiological consequences of significant releases of radioactive materials"* by the mean of off-site emergency response. IAEA stresses that even if the efforts described in the lower levels are expected to be effective in limiting the consequences of severe accidents, *"it would be inconsistent with defence in depth to dismiss off-site emergency plans"* [IAEA1996].

The Publication 109 of the International Commission on Radiological Protection (ICRP) dedicated to the protection of people in emergency exposure situations stresses that *"the importance of planning for emergency response cannot be over-emphasised. No emergency response can be effective without prior planning"* [ICRP109 (44)].

Furthermore, IAEA guidelines on emergency preparedness and response (EP&R) state that *"the government shall ensure that an emergency management system is established and maintained on the territories of and within the jurisdiction of the State for the purposes of emergency response to protect human life, health, property and the environment in the event of a nuclear or radiological emergency."* Moreover, *"once the protection strategy has been justified and optimized and a set of national generic criteria has been developed, pre-established operational criteria (conditions on the site, emergency action levels (EALs) and operational intervention levels (OILs)) for initiating the different parts of an emergency plan and for taking protective actions and other response actions shall be derived from the generic criteria"* [IAEA2015].

1.2. Lessons from the Fukushima accident

The Chernobyl and Fukushima disasters have many common points although they are separated by 25 years. The DEVAST research project in Japan compared the testimonies of refugees from the tsunami and the nuclear disaster [DEVAST2013]. It clearly appears that *"the evacuation from the tsunami can be characterized as an evacuation with warning, preparation and knowledge"* whereas the *"evacuation from the nuclear accident* *can be described as an evacuation without warning, preparation or knowledge. [...] As a result, the evacuation was organised in an ad hoc and chaotic manner, leaving the population in great confusion."*

On paper, in Japan as elsewhere, nuclear emergency plans are based on international standards and all look similar. The counter measures are sheltering, potassium iodate prophylaxis, evacuation and control of foodstuffs.

With 18 nuclear reactors to produce electricity and a research reactor, Ontario should be especially well prepared. Moreover, in USA, there are six power plants located at less than 100 km from the Canadian border. Would Ontario do better than Japan in case of a severe nuclear disaster?

2. Scale of the accident

2.1. International standards

To our knowledge neither the IAEA nor the ICRP stipulate the scale of the accident that should be taken into account for emergency planning and response. IAEA's Basic Safety Standards and guidelines on EP&R stipulate: *"the emergency management system shall be designed to be commensurate with the results of a hazard assessment and to enable an effective emergency response to reasonably foreseeable events (including very low probability events)"* [IAEA2014, IAEA2015]. Furthermore, IAEA states: *"the hazard assessment shall include consideration of:*
(a) Events that could affect the facility or activity, including events of very low probability and events not considered in the design;
(b) Events involving a combination of a nuclear or radiological emergency with a conventional emergency such as an emergency following an earthquake, a volcanic eruption, a tropical cyclone, severe weather, a tsunami, an aircraft crash or civil disturbances that could affect wide areas and/or could impair capabilities to provide support in the emergency response" [IAEA2015].

The Western European Nuclear Regulators Association (WENRA) and the Heads of the European Radiological Protection Competent Authorities (HERCA) both *"consider that the possibility of a severe accident scenario (i.e. Fukushima-like) with no or insufficient information on the plant status cannot be completely ruled out. EP&R arrangements should therefore also cover such cases"* [ATHLET2014]. All European countries endorsed this statement.

French Nuclear Safety Authority use to state on its homepage *"a nuclear accident is always possible. Nevertheless, an accident of the type of Chernobyl (at level 7 of INES) with catastrophic consequences for the population and the environment is hardly conceivable in France[1]".* But after the catastrophe in Japan, it changed its stance in French mass media.

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[1] *« Un accident nucléaire est toujours possible. Néanmoins, un accident du type de Tchernobyl (de niveau 7 sur l'échelle INES), dont les conséquences ont été catastrophiques pour les populations et l'environnement, est peu envisageable en France. ».* http://www.asn.fr/index.php/S-informer/Dossiers/Les-situations-d-urgence/Que-faire-en-cas-d-accident/L-incident-L-accident updated on the 6th of October 2009. Accessed in December 2013. This sentence disappeared when the web site was renewed early 2014.

The head of the French nuclear safety authority has repeated several times[2] that *"a major accident like in Chernobyl or Fukushima cannot be ruled out anywhere in the world, including Europe. We must draw the consequences."* Nevertheless, the French National emergency plan is still scaled for an accident with a limited impact on the environment.

After the Fukushima accident, the German Commission on Radiological Protection (Strahlenschutzkommission, SSK) wrote: *"due to their low likelihood of occurrence, the consequences of incidents now classified as an INES level 7 were not used as a basis for determining requirements in terms of emergency preparedness plans".* It adds that it *"believes that the range of accidents included in emergency response planning should be redefined to more closely reflect an accident's potential impact rather than its likelihood"* [SSK2014]. Consequently, it recommends to consider an INES level 7 to frame emergency plans.

Switzerland has also revised reference scenarios noticing that the source term in Fukushima was larger than what was considered for emergency planning. New scenarios with source terms for iodine and aerosols multiplied by 10, 100 and 1 000 have been introduced [IDA-NOMEX2014].

2.2. Lessons from the Fukushima disaster

In Japan, *"an evacuation on this scale had never been envisioned – let alone exercised – prior to the accident"* [DEVAST2013]. The Nuclear Accident Independent Investigation Commission of the Japanese National Assembly (NAIIC) concluded: *"the expansion of damage caused by this accident is attributed to the insufficient preparedness on the part of the central government and municipal governments in facing a complex disaster involving earthquakes and tsunamis occurring simultaneously with a nuclear disaster.*
The Niigata-ken Chuetsu-oki Earthquake, which occurred on July 16, 2007, triggered multiple troubles and failures, including a transformer fire and a leakage of water containing radioactive substances at the Kashiwazaki-Kariwa Nuclear Power Plant. In response to these outcomes, many pundits requested nuclear power plants to put emergency preparedness measures in place to address complex disasters. However, no integrated efforts had been made by the central government and municipal governments to establish disaster preparedness against complex disasters prior to the accident at the Fukushima Daiichi plant" [NAIIC2012].

The Independent Investigation Commission on the Fukushima Nuclear Accident settled by a private foundation, adds: *"In 2010, for example, the government of Niigata Prefecture, on Japan's western shores, made plans to conduct a joint earthquake and nuclear disaster drill. This was imminently sensible, since just three years before an offshore earthquake had temporarily shut down a TEPCO nuclear power station on the Niigata coastline. But the Nuclear and Industrial Safety Agency (NISA), the nation's main*

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[2] Pierre-Franck Chevet, *Il faut imaginer qu'un accident de type Fukushima puisse survenir en Europe*, interview to Libération, 3rd March 2016
http://www.liberation.fr/futurs/2016/03/03/il-faut-imaginer-qu-un-accident-de-type-fukushima-puisse-survenir-en-europe_1437315
Trente ans après Tchernobyl, « un accident nucléaire majeur ne peut être exclu nulle part », interview to Le Monde, 22nd April 2016

nuclear regulator, advised the local government that a nuclear accident drill premised on an earthquake would cause "unnecessary anxiety and misunderstanding" among residents" [IICFNA2014].

Thus, Prof. Yotaro Hatamura, who headed the *Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company*, concludes in his report: "*It should be assumed that "all possible phenomena would occur". Moreover, it is necessary to recognize that there could be kinds of phenomena, which do not even be recognized as impossible phenomena, in other words, unthinkable phenomena can also occur. […] It is necessary to make full preparations based on the assumption that unthinkable phenomena might occur"* [ICANPS2012].

2.3. In Ontario

The provincial master plan explains: *"a basic offsite effect has been selected to serve as the main basis for nuclear emergency management"* such as *"the impact would mainly be confined to a limited area around the nuclear installation."* The master plan also states: *"an accident or event could occur which could result in a more severe offsite effect, though the probability of such an occurrence is very low"*. Moreover "*the duration of an emission (whether sustained or intermittent) could be several weeks. The largest release of radioactivity would most likely occur during the first few days"* [EMO2009].

Just after the Fukushima accident, the Canadian Nuclear Safety Commission (CNSC) noted: *"the Province of Ontario planning basis for the current nuclear emergency plans and offsite arrangements is a single-unit accident scenario and does not explicitly consider a multi-unit accident scenario"* [CCSN2011]. At the Fukushima dai-ichi NPP, three reactors suffered meltdown.

However, the proposed changes to the nuclear emergency plans do not take into account a large-scale accident.

- ➔ **ACRO urges Ontario authorities to consider that a large-scale nuclear accident might occur and prepare an emergency response plan for it.**

3. Emergency Planning Zones

3.1. International recommendations

According to IAEA, *"in order to be effective the protective actions need to be implemented promptly: first for those located within 3 to 5 km of the nuclear power plant, followed by those located within 15 to 30 km, when conditions are detected in the plant leading to severe damage to the fuel in the reactor core or spent fuel pool. […] The release could also result in deposition of radioactive material resulting in hot spots where the dose to those in the area within days to weeks could exceed the international generic criteria (GC) at which protective actions are justified to reduce the risk of radiation induced cancers (i.e. stochastic effects). This would principally be a concern within about 50 to 100 km of the nuclear power plant"* [IAEA2013].

Consequently, emergency planning zones defined by IAEA [IAEA2015] include:

- A precautionary action zone (PAZ), for which arrangements shall be made for taking urgent protective actions and other response actions, before any significant release of radioactive material occurs, in order to avoid or to minimize severe deterministic effects.
- An urgent protective action planning zone (UPZ), for which arrangements shall be made to initiate urgent protective actions and other response actions, if possible before any significant release of radioactive material occurs, and after a release occurs, on the basis of monitoring and assessment of the radiological situation off the site, in order to reduce the risk of stochastic effects. Any such actions shall be taken in such a way as not to delay the implementation of precautionary urgent protective actions and other response actions within the precautionary action zone.
- An extended planning distance (EPD) from the facility, (beyond the urgent protective action planning zone), for which arrangements shall be made to conduct monitoring and assessment of the radiological situation off the site in order to identify areas, within a period of time that would allow the risk of stochastic effects in the areas to be effectively reduced by taking protective actions and other response actions within a day to a week or to a few weeks following a significant radioactive release.
- An ingestion and commodities planning distance (ICPD) from the facility (beyond the extended planning distance), for which arrangements shall be made to take response actions (1) for protecting the food chain and water supply as well as for protecting commodities other than food from contamination following a significant radioactive release and (2) for protecting the public from the ingestion of food, milk and drinking water and from the use of commodities other than food with possible contamination following a significant radioactive release.

Suggested radii for emergency zones are [IAEA2013]:

Emergency zones and distances	**Suggested maximum radius**	
	> 1 000 MW(th)	**100 to 1 000 MW(th)**
Precautionary action zone (PAZ)	3 to 5 km	
Urgent protective action planning zone (UPZ)	15 to 30 km	
Extended planning distance (EPD)	100 km	50 km
Ingestion and commodities planning distance (ICPD)	300 km	100 km

At the European level, the so-called AtLHET task force settled by safety and radioprotection authorities considers that as improbable Fukushima-like severe accidents might be, EP&R arrangements must be prepared for such cases, too. Consequently "*according to the current studies, international standards and methods used for emergency preparedness and response, an accident comparable to Fukushima would require protective actions such as evacuation to around 20 km and sheltering to around 100 km. These actions would be combined with the intake of stable iodine*" (ITB) [ATHLET2014]. Such scales mean cross-boundary accidents.

Thus, *"HERCA and WENRA consider that in Europe:*

- *evacuation should be prepared up to 5 km around nuclear power plants, and sheltering and ITB up to 20 km;*
- *a general strategy should be defined in order to be able to extend evacuation up to 20 km, and sheltering and ITB up to 100 km;*
- *nuclear and radiation safety authorities in Europe should continue attempts to promote compatible response arrangements and protection strategies amongst the European countries"* [ATHLET2014].

3.2. Lessons from Fukushima

In Japan in 2011, the inappropriate size of the EPZ hampered evacuation and lead to confusing decisions. The Fukushima Nuclear Accident Independent Investigation Commission of National Diet of Japan [NAIIC2012] writes: *"Fukushima Prefecture, acting on its own accord, issued an evacuation order for residents within 2km of the nuclear power plant at 20:50 on March 11, approximately 30 minutes before the national government's decision to set the evacuation area to a 3km radius around the Fukushima Daiichi Nuclear Power Plant. […] The 2km radius was determined by the prefecture as the bare minimum distance considering the 2km evacuation radius used for residents in past comprehensive nuclear emergency preparedness drills."*

The evacuation orders were later extended to 10 and 20 km from the NPP. *"A 10km radius zone was chosen simply because it was the maximum area for an Emergency Planning Zone (EPZ) as set out in the Disaster Prevention Plan; it was not decided on the basis of any kind of concrete calculations or rational grounds. As for the 20km-radius evacuation zone, due to the progression of the situation, including the hydrogen explosion in Unit 1, a radius of 20km was decided upon simply because of some people's subjective opinions. This can hardly be called a rational decision."* [NAIIC2012]

It is worth knowing at this stage that 80% of the radioactive fallouts from the Fukushima NPP when towards the Pacific Ocean. Japan would have faced a significant impact on longer distances if downwind zones were inhabited.

As a consequence, the new guidelines of the Japanese Nuclear Regulation Agency define a *Precautionary Action Zone* with a radius of 5 km with immediate evacuation in case of a general nuclear emergency, an *Urgent Protective action Planning Zone* between radii of 5 to 30 km with protective action depending on the severity of the accident. There is also a *Plume Protection Planning Area* between radii of 30 to 50 km where iodine tablets are available and where protective action might be taken if necessary [NRA2012, NRA2013].

On the 16th of March 2011, the U.S. Nuclear Regulatory Commission (NRC) recommended that U.S. citizens within 80 km of the Fukushima Daiichi plant evacuate. NRC justifies this recommendation as a conservative estimate based on limited and often conflicting information about the exact conditions of the reactors and spent fuel pools at the power plant.

But NRC considers that the 10-mile (16 km) and 50-mile (80 km) emergency planning zones established in 1978 remain adequate. This is not the point of view of the United States Government Accountability Office [GAO2013]: *"To better inform radiological* *emergency preparedness efforts, GAO recommends that NRC obtain information on public awareness and likely public response outside the 10-mile zone, and incorporate insights into guidance, as appropriate."*

3.3 In Ontario

In Ontario the provincial master plan [EMO2009] states: *"The area around the boundary of a nuclear installation for which a nuclear emergency response plan is made shall be divided into the following zones:*

(a) Contiguous Zone
The zone immediately surrounding the nuclear installation. Priority evacuations, if necessary, shall be undertaken within this area because of its proximity to the source of the potential hazard.

(b) Primary Zone
The zone around the nuclear installation within which detailed planning and preparedness shall be carried out for measures against exposure to a radioactive plume. (The Primary Zone includes the Contiguous Zone).

(c) Secondary Zone
A larger zone within which it is necessary to plan and prepare measures to prevent ingestion of radioactive material. (The Secondary Zone includes both the Primary and Contiguous Zones)."

The approximate or nominal radii for these zones are given in Table 1.

Table 1: The approximate or nominal radii of the zones for the designated nuclear installations in Ontario as measured from the venting or release stacks [EMO2009]

Zones	Pickering, Darlington, Bruce	Chalk River Laboratories	Fermi 2
Contiguous Zone	3 km	None	None
Primary Zone	10 km	9 km	23 km
Secondary Zone	50 km	50 km	80 km

For the Fermi 2 NPP located in USA, the radii are those used in USA. It is worth noticing that the New Brunswick Nuclear Emergency Plan introduces a 20-km protection zone around the Point Lepreau power station in which residents must be informed and prepared [NB2012].

Such disparities within the province, the country and with the neighboring country can lead to dysfunctions and misunderstandings. In Europe, too, there are considerable disparities between countries, which are sources of concern for the authorities, because a serious accident will necessarily be transboundary. This will result in a source of tension on both sides of the border, such as after the Chernobyl disaster. The Heads of the European Radiological protection Competent Authorities (HERCA) calls for harmonization as differences on both sides of the border can lead to distrust of the population [HERCA2014]. The Canadian authorities would gain credibility if they could harmonize their contingency plans. However, this will only be the case if the most protective measures for the population are adopted, irrespective of local political or economic interests.

Moreover, distances considered in Canadian emergency plans are shorter than international standards and would be too short in case of a severe nuclear disaster. Preparation zones should be enlarged to cope with large-scale radioactive release.

- ➔ **Canada should harmonize its contingency plans to ensure optimum protection for potentially exposed populations. Larger preparation zones are necessary.**

3.4. Number of inhabitants in emergency preparation zones

Table 2 shows that the number of people living around nuclear power plants in Ontario is much larger than around the Chernobyl or Fukushima power plants. This is particularly the case for Pickering and Darlington power plants located near Toronto. For US power plants, most of the affected people live in US, but many of them may be forced to evacuate to Canada.

Such large numbers of potentially affected persons will lead to additional difficulties in the event of a severe accident. Protective measures should be well prepared.

Table 2: Estimated number of inhabitants around some nuclear power plants. Sources: [Nature2011] and [EMO2009].

Site/radius	10 km	30 km	75 km	150 km
Tchernobyl	61 000	135 000		
Fukushima		172 000	1 730 000	7 700 000
Pickering (Canada)	**256 361**	**2 200 000**	**5 830 000**	**10 860 000**
Darlington (Canada)	121 010	440 000	4 350 000	10 620 000
Bruce (Canada)	4 011	30 000	170 000	1 520 000
Fermi 2 (USA)		*380 000*	*5 660 000*	*10 880 000*
Perry (USA)		*270 000*	*2 350 000*	*6 870 000*
Sources	Data 2006 [EMO2009]	Data 2011 [Nature2011]		

4. Sheltering

4.1. International standards

Publication 109 of the ICRP explains: *"sheltering is the use of the structure of a building to reduce exposure from an airborne plume and/or deposited materials. Solidly constructed buildings can attenuate radiation from radioactive materials deposited on the ground and reduce exposure to airborne plumes. Buildings constructed of wood or metal are not generally suitable for use as protective shelters against external radiation, and buildings* *that cannot be made substantially airtight are not effective in protecting against any exposures"* [ICRP109 (B4)].

It also states that sheltering is not recommended for longer than approximately 2 days. IAEA consider that *"sheltering should not be used for more than a day unless arrangements have been made in advance"* [IAEA2013].

Publication 63 of the ICRP stipulates that *"it has been estimated on a generic basis that sheltering will almost always be justified provided that an averted effective dose of 50 mSv can be achieved during the time considered feasible for sheltering. Optimised levels will be lower but not by more than a factor of 10 when consideration is given to specific accident conditions and sub-groups of the population"* [ICRP63(62)].

French national guidelines consider that sheltering should be limited in time because its efficiency decreases with time. Limiting factors are due to the penetration of radioactive elements into buildings, the need of food supply and the potential separation of the family members. Children might be at school and parents at workplace. *"An actual duration of the order of half a day can be used"* [SGDSN2014]. French guidelines add that if the discharge is long or threatens to amplify, the sheltering should be followed by evacuation at discharge. The lifting of sheltering is accompanied by information specifying behaviours.

In France, safety rules require the sheltering when forecasts of the exposure of the population exceed an effective dose of 10 mSv for the whole body [SGDSN2014]. It is 5 mSv in Belgium [ACRO2015].

4.2. Lessons from Chernobyl and Fukushima

In Chernobyl and Fukushima, massive discharges lasted for about ten days. The shelter in place must then be conceived as a means of preparing for evacuation.

4.3. In Ontario

The Provincial nuclear emergency response plan stipulates: *"for those areas where sheltering is expected to be required for more than 24 hours, evacuations should be considered"* [EMO2009]. This is in agreement with international standards.

Regarding the operational intervention level, Health Canada recommends shelter in place *"if the action will avert a dose of at least 5 mSv over a period of 1 day. This value is consistent with IAEA recommendations of 10 mSv in two days, but recognizes that the effectiveness of sheltering is significantly decreased after about 1 day"* [HC2003].

In Ontario, sheltering will be triggered as soon as the predictable dose in an area reaches or exceeds a value between 1 and 10 mSv [EMO2009]. Moreover, *"in order to reduce dose, sheltering may be considered for areas likely to receive doses below the lower Protective Action Level for sheltering"* [EMO2009]. Local plans specify: *"sheltering may be utilized as a protective measure if there is insufficient time to safely evacuate an area"* [Durham2011].

To be operational, this shelter in place must benefit from an effective warning system extended to all potentially affected populations who should have received in advance the necessary information and the instructions to be followed. The public concerned includes individuals, communities (schools, health and social institutions, etc.), businesses, shopping malls, leisure parks, etc. Given the chosen intervention limit (1 mSv), the information should be extended far beyond the primary intervention zone. It is also stated: *"in general, all sectors adjacent to those being evacuated will be ordered to shelter"* [Durham2011].

It should be noted, as stated by the ICRP, that wooden houses do not adequately protect from external exposure and that shelter is not recommended. The Durham Regional Plan recommends: *"if possible, go to a basement or a ground floor room with no windows"* [Durham2011]. How do the authorities intend to do for dwellings where this is not possible? Especially when there are children, more sensitive to radiation. Are the inhabitants concerned informed?

5. Iodine prophylaxis

5.1. International standards

5.1.1. Justification

There is an overwhelmed agreement that radioactive iodine released during a nuclear accident is the main cause of the increase of thyroid cancers among young people. As a consequence, thyroid blocking is an important way to prevent dose to the gland in case of exposure by inhalation and ingestion of radioiodines.

IAEA explains: *"the uptake by the thyroid gland of radioiodine from inhalation can be reduced by taking stable (nonradioactive) iodine. This is called iodine thyroid blocking (ITB) or stable iodine prophylaxis because the stable iodine saturates the thyroid, greatly reducing the absorption of the radioactive iodine. […] The dose from inhalation of radioactive iodine by those in the PAZ and UPZ can be sufficient to result in severe deterministic effects in the thyroid and foetus, and sheltering or evacuation performed after the start of a release may not provide sufficient protection to prevent these effects. Therefore, in order to reduce the possibility of these effects, it is necessary for the ITB agent to be pre-distributed so that it can be immediately taken by those in homes, schools, workplaces, hospitals and other special facilities within the PAZ and UPZ with instructions for use, so that it can be taken immediately upon declaration of a General Emergency (detection of conditions in the nuclear power plant indicating that a release is possible). Pre-distribution is necessary because it may not be possible to distribute the ITB agent during an emergency in the time required for it to be effectively applied"* [IAEA2013].

Posology is complicated because, *"to obtain the maximum reduction of the radiation dose to the thyroid, stable iodine should be administered before any intake of radioiodine, or as soon as practicable thereafter. If stable iodine is administered orally within 6 h preceding the intake of radioactive iodine, the protection provided is almost complete; if stable iodine is administered at the time of radioiodine inhalation, the effectiveness of thyroid blocking* *is approximately 90%. The effectiveness of the measure decreases with delay, but the uptake of radioiodine can be reduced to approximately 50% if blocking is carried out within a few hours of inhalation"* [ICRP109 (B3)]. It is then better to have iodine tablets at hands to be able to administrate them at the optimum moment.

5.1.2. Intervention levels

There are various definitions of the dose to the thyroid: absorbed dose, equivalent dose, with their own units, milligray (mGy) and millisievert (mSv) respectively. International recommendations use either one or the other. But applied to the impact of radioiodine to thyroid, both units are equivalent. We can replace one by the other.

Publication 103 of ICRP recommends that stable iodine is administrated if the equivalent dose to the thyroid might exceed a value fixed between 50 and 500 mSv. IAEA considers that an absorbed dose of 100 mGy by thyroid is a generic optimized value [EC-TREN2010]. "*Notwithstanding the generic recommendation*, WHO considers *that it is appropriate to consider the differing risks for different age groups when developing detailed emergency plans, and also the possibility of differential administration of stable iodine prophylaxis. In this way, the greater need of children for stable iodine and the greater risk of side effects in the elderly, can be separately catered for."* Consequently, WHO recommends *"planning for stable iodine prophylaxis for children should ideally be considered at 1/10th of the generic intervention level, that is at 10 mGy avertable dose to the thyroid. This level is also appropriate for pregnant women."* WHO also considers that *"for adults over 40, the risk of radiation-induced thyroid cancer is presumed to be close to zero. For this group, the implementation of stable iodine prophylaxis is determined by the need to ensure prevention of deterministic effects"* [WHO1999].

Regarding operational intervention levels in Europe, situation varies among countries. Some stick to the IAEA guidelines. France, Belgium, Germany, Luxembourg and Switzerland agreed to adopt the lowest value of ICRP, i.e. 50 mSv. Belgium and some other European countries also introduced a 10 mSv level for children and lactating women [EC-TREN2010].

5.1.3. Extend of the distribution of iodine tablets

In Europe, distribution of iodine tablets range between a 5-km-zone around the NPP in Finland to 50 km in Lithuania [EC-TREN2010]. This range has been debated after the Fukushima accident. The European AtHLET task force concluded that it might be necessary to protect the thyroid up to 100 km from the NPP in case of an accident [ATHLET2014].

In France, the government decided in 1997 to organize the distribution of iodine tablets to people living in the EPZ within a radius of 10 km around nuclear power plants. Stocks should be permanently available in the EPZ and beyond. French government announced in April 2016 that iodine distribution will be extended to a radius of 20 km around NPP.

In Belgium, iodine tablets are also handed to the population within 20 km of a nuclear reactor. Outside of these zones there are large decentralized stocks that can be distributed to the population. Furthermore, every pharmacy in the country has a sufficiently large stock of iodine-containing basic material, allowing a quick production of emergency rations[3]. Government announced in January 2017 that iodine distribution will be extended to the whole country, corresponding to a radius up to 100 km, with an emphasis on children and pregnant and lactating women. This is in agreement with the recommendations of the Superior Health Council that also considers that it may be necessary to protect the thyroid up to distances of several tens or hundreds of kilometres [CSS2015] and with the recommendations of the scientific council of the Nuclear Safety Authority [AFCN2016].

In 1993 the Swiss government began handing out iodine tablets to residents living within 20km of a nuclear reactor. In 2014, it was decided to extend the distribution up to 50 km. The number of people receiving a box with 12 tablets had nearly quadrupled to 4.6 million, covering residents in the cities of Zurich, Basel and Lucerne. This is more than half of the Swiss population. Luxembourg distributed iodine tablets to all its population. The most distant inhabitants are about one hundred kilometres away from the nuclear plant.

German commission for radiological protection calculated that *"it may be necessary to administer iodine blockade to children, young people and pregnant women who are much further away from the plant (>100 kilometres) but within the dispersal direction. These calculations prove that dose levels may be exceeded at distances of up to 200 kilometres away from a plant. Distances of over 200 kilometres were not investigated as a radius of 200 kilometres around German plants and plants located near international borders would cover almost the whole of Germany"* [SSK2014].

5.1.4. Second intake

One dose of stable iodine will provide protection for approximately 24 h. But massive release of radioactive elements into the atmosphere lasted 10 days for both Chernobyl and Fukushima nuclear disasters. ICRP considers that *"normally, evacuation would be preferred to administration of a second dose. Where the potential for prolonged releases indicates that multiple administrations to a sheltering population may be required, the emergency plan should address how this will be achieved. Multiple administrations should not be considered unless a release is actually detected more than 24h after the first administration, and evacuation is not practicable. Ideally, stable iodine prophylaxis should not be used to provide protection against contamination of food. Wherever practicable, restrictions on food should be implemented to provide protection against intake by ingestion"* [ICRP109 (Table C3)].

Publication 109 of ICRP stresses: *"there is another measure that prevents radioiodine intake directly (restriction of potentially contaminated food consumption), thyroid blocking is considered to be primarily used for reduction of doses that result from inhalation. Iodine thyroid blocking should only be used to reduce the uptake of ingested radioiodine if it is impossible to provide supplies of uncontaminated food, especially for children and particularly in relation to milk; even if this is the case, iodine thyroid blocking*

[3] http://www.nuclearrisk.be/campaign-2011/distribution-iodine-tabs/distribution-zones-iodine

is intended for relatively short periods of time, since efforts should be made to provide supplies of uncontaminated food as soon as possible" [ICRP109 (B2)].

In Europe, "*a second intake is envisaged in most countries, mainly in case of long-lasting releases, with a similar or lower dosage than for the first intake. In the United Kingdom and Belgium, stable iodine prophylaxis may be used also as a temporary measure to provide protection for young children against the ingestion exposure pathway, until food restrictions can be imposed. A second intake is generally envisaged 24 hours after the first one. The second intake is sometimes only envisaged for the most radiosensitive population, i.e. newborns, young children, pregnant and breast-feeding women. In Romania stable iodine may be administrated several times on a maximum of ten days"* [EC-TREN2010].

The Belgium Superior Health Council stresses that radioactive fallouts can last several days, even weeks and that there is no clear strategy of optimized protection in most emergency plans [CSS2015]. A research program on this issue was launched in Europe and the results are expected for 2017[4].

5.2. Lessons from Chernobyl and Fukushima

It is worth noticing that iodine prophylaxis was not used in former USSR after the Chernobyl disaster. In Japan, almost not as iodine tablets were not distributed before the disaster. Stockpiles were stored locally, but the government's nuclear emergency response headquarters and the prefectural government failed to give proper instructions to the public. Consequently, only a very small number of residents in the surrounding area took them [NAIIC2012].

According to the Chernobyl forum, *"statistics from the national registries of Belarus and Ukraine indicate that the total number of thyroid cancers among those exposed under the age of 18, is currently close to 5 000. The numbers differ slightly depending on the reporting methods, but the overall number observed in the three countries is certainly well above 4000"* [IAEA2006]. UNSCEAR, the United Nations Scientific Committee on the Effects of Atomic Radiations, reports 6 848 cases of thyroid cancers between 1991 and 2005 among those under age 18 in 1986. It adds that the dramatic increase in incidence in 1991-1995 among children under age 10 was associated with the accident. The increase in the incidence among children and adolescents began about 5 years after the accident and persisted until 2005 [UNSCEAR2008].

After Chernobyl disaster, there has been an excess thyroid cancer incidence even in areas where the mean dose to the thyroid in children was estimated below than 100 mGy[5].

The World Health Organisation (WHO) notes that after the Chernobyl disaster, the increase in incidence has been documented up to 500 km from the accident site [WHO1999].

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[4] IRSN, *Lancement du projet ANR Priodac*, 15 avril 2014 http://www.irsn.fr/FR/Larecherche/Actualites_Agenda/Actualites//Pages/2014-04-15-lancement-projet-ANR-PRIODAC.aspx

[5] P. Jacob et al, *Thyroid cancer risk to children calculated*, Nature 392 (1998) 31

In the case of the Fukushima dai-ichi Nuclear Power Plant accident, the area where a thyroid equivalent dose due to inhalation of radioactive iodine from the plume might have exceeded the criteria for iodine prophylaxis of IAEA extended to about 50km from the nuclear power plant [NRA2012]. It would have been longer distances if the main downwind zone were not the ocean but inhabited territories.

In Japan, the Fukushima Medical University has screened the thyroid of 368 000 children in Fukushima prefecture. As of the 31st of December 2016, after a first echography, 101 children were found to have developed a thyroid cancer confirmed by surgery. One case happened to be benign and there are 14 other suspected cases. Although the occurrence frequency is higher than what is usually observed, Japanese authorities keep claiming that it is not due to the nuclear disaster. They rather claim that such a number is due to the systematic screening. If it is the case, why surgery was necessary? These children could have lived several years with their thyroid gland[6]. A second screening campaign was launched in May 2014. Among 270 500 children having a second echography test, 69 are suspected to have a thyroid cancer, including 44 confirmed cases. On these 68 cases 63 had no problem detected during the first screening [FMU2017]. Japanese authorities continue to consider that this is not due to the nuclear disaster, but such a conclusion is highly debated.

A recent epidemiological study[7] published in a scientific journal with referees, contests the official point of view and concludes that the excess of thyroid cancers is unlikely to be explained by a screening surge. The authors don't see any other explanation than radioactivity.

Health agency in Québec, Canada, explains that *"the efficiency of iodine prophylaxis was demonstrated in Poland where stable iodine was administrated to 10.5 millions children and 7 millions adults in the aftermath of the Chernobyl accident. Recommended dose was 15 mg for new-born's, 50 mg for children less than 5 years old and 75 mg for others, including pregnant women. Radioactive dose was cut by 40% when the pill was administrated three days after the accident and by 25% when it was four days after. This led to a 5 rem (50 mSv) reduction of the dose to the thyroid (Nauman et Wolff, 1993). No increase of the occurrence of thyroid cancers was observed. On the contrary, in Belarus, were iodine prophylaxis was not implemented, a 100-fold increase of this cancer was observed among children following the Chernobyl accident"* [ASSS2012]. In particular, it was the case in the Brest district, the second most affected after Gomel, that is located near the Polish border.

One of the lessons from Fukushima drawn by Anand Grover, Special Rapporteur of the Human Rights Council, in his report about the situation in Japan, is that *"the State should take all efforts to ensure that such health goods as stable iodine tablets are made available*

[6] Mizuho Aoki, *Experts question Fukushima thyroid screening*, The Japan Times, Jul 31, 2014 http://www.japantimes.co.jp/news/2014/07/31/national/science-health/experts-question-fukushima-thyroid-screening/

[7] Tsuda et al, thyroid cancer detection by ultrasound among residents ages 18 Years and Younger in Fukushima, Japan: 2011 to 2014, Epidemiology: May 2016 - Volume 27 - Issue 3 - p 316–322 http://journals.lww.com/epidem/Citation/2016/05000/Thyroid_Cancer_Detection_by_Ultrasound_Among.3.aspx

and accessible, in a timely manner, to mitigate the effect of radioactive iodine on the health of the exposed population" [HRC2013].

5.2. In Ontario

Ontario recently decided to distribute iodine tablets to residents, businesses and other institutions within a radius of 10 km around nuclear power plants by December 2015. Beyond that, in the secondary zone, stocks will be prepared for the "sensitive" population, ie, children under 19, pregnant and breastfeeding women [CNSC2015a]. This is a good decision but the distribution should be extended.

The intervention level is established at a dose of 50 mSv to the thyroid for all target populations. The guidelines state that "*unless they have a contraindicated condition, no person in the Primary Zone or otherwise affected by the emergency should ever be denied KI if they request it*" [MHC2014a].

Ontario's strategy for the primary zone was to distribute iodine for two days by providing 5 pills per person [CNSC2015a].

- ➔ **Ontario should extend the distribution of iodine tablets up 100 km from nuclear power plants. Canada should introduce more protective intervention levels for children, pregnant and breast-feeding women. Clear information related to posology and multiple intakes should be provided to the populations.**

5.3. Warning and information to the populations

It is not possible for the public to know if the thyroid dose is likely to be exceeded and when iodine tablets should be taken in the event of an accident. Good protection implies that the authorities can quickly calculate the potentially affected areas and immediately inform affected persons. In Japan, this was not the case during the Fukushima disaster.

Early warning of the population with the transmission of relevant information is essential to the success of crisis management. This requires a redundancy of means of communication, including sirens, mass media and telephones. The information must arrive on time. Regarding sirens, the Ontario Master Plan says that *"the public alerting system in the Contiguous Zone (0-3 km) must provide, within 15 minutes of initiation, warning to practically 100% of the people in the Contiguous Zone at that time, whether they be indoors or outdoors, and irrespective of the time of day or year."* But for the primary zone (3-10 km) it is only required that *"alert signal will cover that geographical area as defined, but does not presume that practically 100% of all persons within that geographical area will necessarily hear the public alerting signal"* [EMO2009].

Have these warning and communication means been tested by means of a survey to find out the percentage of people who heard the alert and understood the message?

6. Evacuation

Evacuation is the most complicated protection measure, as it requires good coordination between various stakeholders, relevant information to the public and heavy logistics. It often has to be decided when the situation at the NPP is still uncertain at the very beginning of the emergency. Such a difficult measure requires good preparedness that has to be carefully evaluated. Evacuation is also the most disruptive protection measure for the populations. Especially when evacuation eventually leads to relocation.

6.1. International standards

ICRP states: *"evacuation represents the rapid, temporary removal of people from an area to avoid or reduce short-term radiation exposure in an emergency exposure situation. It is most effective in terms of avoiding radiation exposure if it can be taken as a precautionary measure before there is any significant release of radioactive material. Generally, evacuation is not recommended for a period of longer than 1 week"* [ICRP109 (B6)].

Evacuation is triggered either as a preventive measure or following release of radioactive materials. *"Preventive evacuation is the most disruptive of the early protective actions. The difficulty in making a decision to evacuate prior to a release of radioactivity lies in the limited amount of information that may be available. Judgment is required on the nature of the accident, the chances of escalation and whether the doses that might be received are high enough to warrant the risks, anxiety, disruption and costs associated with evacuation"* [ICRP63(63)].

"In the context of developing response plans for emergency exposure situations, the Commission recommends that national authorities should set reference levels between 20 mSv and 100 mSv effective dose (acute or per year, as applicable to the emergency exposure situation under consideration)" [ICRP109(b)]. This most recent recommendation of the ICRP is not so easy to implement. Therefore, it adds that *"however, the levels of averted dose recommended in Publication 63 for optimisation of protection in terms of individual protective measures may still be useful as inputs to the development of the overall response."* The reference level for triggering an evacuation is recommended to be between 50 and 500 mSv in a week.

IAEA explains that *"evacuation within the PAZ starting before a release combined with ITB is the preferred protective action in the event of an emergency involving severe damage to the fuel for all reactors with power levels greater than 100 MW(th). This is needed to prevent severe deterministic effects and to prevent doses exceeding the international generic criteria calling for urgent protective or other response actions to be taken. For reactors with power levels greater than 1000 MW(th), evacuation within the UPZ is needed in order to prevent doses exceeding the international generic criteria calling for urgent protective or other response actions to be taken"* [IAEA2013].

Furthermore, *"evacuation of patients and those requiring specialized care from the PAZ and UPZ would be to locations outside of the EPD to ensure that further evacuations would not be required after a release. Concerns have been raised over the possibility of traffic congestion or 'shadow evacuations' causing a delay in an evacuation of the PAZ. For this* *reason, a phased evacuation (i.e. evacuating the PAZ to outside the UPZ first, followed by evacuation of the UPZ) is recommended"* [IAEA2013].

6.2. Lessons from Three-Mile-Island and Fukushima

The experience of Three-Mile-Island (TMI) should to be kept in mind. On the 30th of March 1979 the governor of Pennsylvania advised all pre-school aged children and pregnant women to evacuate a 5-mile (8 km) radius around TMI, everyone else within the 10-mile (16 km) EPZ was told to stay indoors. Of this portion of the population, only 3 500 people were expected to evacuate. However, it was estimated that 200 000 people within a larger 25-mile (40 km) radius chose to evacuate. Approximately 663 500 people were at risk within 20 miles (32 km) of TMI[8].

A shadow evacuation is defined as an evacuation of people from areas outside an officially declared evacuation zone. The shadow population is considered in the analysis to account for any effect of this population group impeding the evacuation of those under evacuation orders. Population estimates for the shadow evacuation in the 10 to 15 miles (16 to 24 km) area beyond the EPZ should be provided by sector [USNRC2011a].

To better inform radiological emergency preparedness efforts, US Government Accountability Office (GAO) recommends that NRC obtain information on public awareness and likely public response outside the 10-mile zone, and incorporate insights into guidance, as appropriate. NRC generally disagreed with GAO's finding, stating that its research shows public response outside the zone would generally have no significant impact on evacuations. Nevertheless, GAO continues to believe that its recommendation could improve radiological emergency preparedness efforts and is consistent with NRC guidance [GAO2013].

In Japan, *"a total of 146 520 residents were evacuated as a result of the government's evacuation orders. However, many residents in the plant's vicinity evacuated without accurate information. Unaware of the severity of the accident, they planned to be away only for a few days and evacuated with only the barest necessities. Evacuation orders were repeatedly revised as the evacuation zones expanded from the original 3-kilometer radius to 10 kilometres and later, 20 kilometres, all in one day. Each time the evacuation zone expanded, the residents were required to relocate. Some evacuees were unaware that they had been relocated to sites with high levels of radiation. Hospitals and nursing homes in the 20-kilometre zone struggled to secure evacuation transportation and find accommodations; 60 patients died in March from complications related to the evacuation. Frustration among the residents increased"* [NAIIC2012].

In Japan there were numerous complaints about evacuation orders that required the residents living near the nuclear plants to evacuate so many times. Over 70% of residents from the areas near the Fukushima Daiichi and Fukushima Dai-ni plants

[8] J.H. Johnson and D.J. Zeigler, *Socio-Economic Planning Science* **20** (1986) 165; Susan Cutter and Kent Barnes, *Disasters* **6** (1982) 116
http://desastres.unanleon.edu.ni/pdf/2003/agosto/PDF/ENG/DOC540/doc540-contenido.pdf

(Futaba, Okuma, Tomioka, Naraha, Namie) had to evacuate more than four times [NAIIC2012].

Evacuation of vulnerable people, especially bedridden people in hospitals was probably the most dramatic aspect of the evacuation during the nuclear disaster in Japan. About 45 of the 440 patients of the Futaba hospital and the nearby nursing home for the elderly died [GPI2012]. Elderly people who need special care are also in danger in case of evacuation.

In Japan, a recent study investigated evacuation-related mortality risks among elderly people from five nursing homes in Minamisoma city, Fukushima Prefecture. Mortality risk was 2.68 higher after the accident than before. Authors conclude: *"high mortality, due to initial evacuation, suggests that evacuation of the elderly was not the best life-saving strategy for the Fukushima nuclear disaster. Careful consideration of the relative risks of radiation exposure and the risks and benefits of evacuation is essential. Facility-specific disaster response strategies, including in-site relief and care, may have a strong influence on survival. Where evacuation is necessary, careful planning and coordination with other nursing homes, evacuation sites and government disaster agencies is essential to reduce the risk of mortality[9]."*

Japanese NAIIC insists "*that it is essential to prepare new countermeasures, utilizing lessons learned from the accident, in order to prevent future situations in which hospitalized patients who are unable to evacuate under their own power during a disaster are left behind, resulting in many deaths. It is necessary for prefectures (including Fukushima Prefecture) and municipalities where nuclear plants are located, and for medical institutions in the vicinity of nuclear plants, to consider and develop revisions of their nuclear disaster response manuals, disaster prevention drills, means of communication, coalitions with other municipalities in case of an accident, and so on, in order to better provide evacuation assistance to hospitalized patients in the case of a disaster*" [NAIIC2012].

As a consequence, new Japanese guidelines recommend: "*the triage system to set priority for carry of patients and the carry system to enable to start a curative treatment in 60 minutes in nuclear accident should be arranged in preparation for the occurrence of severely injured patients.*
Taking into consideration hospitalized patients or persons requiring support in welfare institutes or large amounts of injuries in disaster, ways to carry and provision of medical care for large amounts of patients when nuclear accident occurred should be reviewed and prepared. For preparation of carry of many patients, arrangements of securement of root and acceptance, preparation of carrying means, attendance of medical staffs, screening, and other pertinent matters are necessary. Securement of exclusive personnel for arrangements of carry of patients is recommended. Collaboration with medical institutions at nearby prefectures should be promoted for medical care in nuclear disaster.
For hospitalized patients and elderly people, it may be inappropriate to evacuate quickly and temporally sheltering in institutions may be a suitable measure for radiation

[9] Nomura S, Gilmour S, Tsubokura M, Yoneoka D, Sugimoto A, et al. (2013) *Mortality Risk amongst Nursing Home Residents Evacuated after the Fukushima Nuclear Accident: A Retrospective Cohort Study.* PLoS ONE 8(3): e60192
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0060192

protection until receiving institutions designated, because of health risk associated with carry of patients" [NRA2012].

6.4. Assessment

US NRC guidance emphasizes the importance of verifying the committed resources, such as buses and ambulances, required to support evacuation of the transit dependent and school populations, as well as people with disabilities and those with access and functional needs. Special facility residents are those who reside in special facilities and are dependent upon facility personnel for transportation in an emergency. This includes, but is not limited to, hospitals, nursing homes, jails, and prisons. Special facility personnel are counted in the special facility population group [USNRC2011a].

US regulator request an evacuation time estimate (ETE) that is a calculation of the time to evacuate the plume exposure pathway emergency planning zone [USNRC2011a]. Research shows that a small percentage of the public, about 10%, takes a longer time to evacuate. Therefore, the time to evacuate 90% and 100% of the population should be provided in the ETE study. US NRC guidance also establishes the need to include a 20% shadow evacuation in the analysis of evacuation time estimates.

This guidance document details the process for the development of ETEs for four population segments including:

- Permanent residents and transient population;
- Transit dependent permanent residents;
- Special facility residents (e.g., hospitals, prisons, nursing homes, etc.); and
- School populations.

State and local emergency response plans typically include early protective actions for evacuation of schools prior to the general public if time allows. However, the development of ETEs should consider that school evacuations begin with the same initial notification provided to the general public. Schools present a unique issue with the expectation that some students may be picked up by parents, relatives, or friends, which may reduce the student population requiring bus transportation.

Special events like festivals or sporting events occur within most EPZs and can attract large numbers of transients to the EPZ for short periods of time. To avoid double-counting transients and permanent residents, it is recommended to indicate the percentage of permanent residents of the EPZ assumed to be at special events.

Scenarios include season, day of the week, time of day, weather conditions, special events, roadway impact, or other circumstances that should be assessed. The adverse weather condition is intended to represent weather conditions that are probable within the region. It is not necessary to evaluate those adverse weather conditions that may occur at frequencies of 100 years or longer.

The Evacuation Time Estimate of Indian Point NPP has 400 pages[10].

[10] http://www.lohud.com/assets/pdf/BH200923215.PDF

6.5. In Ontario

6.5.1. General guidelines

Federal guidelines recommend evacuation *"if the action will avert a dose of at least 50 mSv over a period of up to 7 days".* However, "*during an emergency, decisions makers may choose to evacuate at lower levels if it can be carried out quickly and easily, if only a small population is affected, or if it will be for a shorter length of time. Conversely, complications could arise if the weather conditions are adverse at the time when the evacuation is being considered. In such a case the dose criterion for evacuation can be raised significantly without reaching deterministic threshold, although the increased risk of stochastic effects needs to be balanced against the physical risk of the evacuation*" [HC2003].

In the Ontario Emergency response plan, the Protective Action Level (PAL) for evacuation range from an effective dose of 10 to 100 mSv: *"The PALs for exposure control measures are prescribed as a range for each protective measure because the decision on applying a protective measure is based not only on technical factors but also on operational and public policy considerations. To enable these considerations to be applied, it is appropriate to provide decision-makers with technical advice ranging between when a measure* ***should*** *be considered for application (on purely technical grounds) and when it becomes* ***necessary*** *on the same grounds)"* [EMO2009].

Priority evacuations, if necessary, shall be undertaken within the Contiguous Zone because of its proximity to the source of the potential hazard. Traffic control plans should be prepared in advance in order to keep traffic flowing smoothly on the main evacuation routes. It may also be initiated when spontaneous evacuations begin to occur [EMO2009].

The regional plan for Durham [Durham2011] states that the majority of the evacuees will use their own means of transportation. However, regional and municipal authorities have to provide means of transportation for the evacuation of people who cannot evacuate on their own with specific plans for schools and hospitals.

We don't know if these evacuation plans exist and if there were assessed.

- ➔ **Large-scale evacuation should be planned and assessed by authorities.**

6.5.2. Evacuee Centres

"Evacuee Centres are facilities set up by the designated (host) municipality to provide shelter, food, and other services to people who have been evacuated as a result of a nuclear emergency. While it is expected that most people will find their own accommodation, lessons learned from major evacuations, including Hurricane Katrina (2005), indicate that 10-20% of the total number of evacuees may require accommodation to be provided to them. Municipal nuclear emergency plans shall provide details regarding the selection, resourcing and staffing of facilities to be used as Evacuee Centres" [EMO-GSUO2009].

It is surprising that the necessary capacity is not better assessed. The population density is such around nuclear power plants that some per cents represent a lot of people. The choice of designated host municipalities is also surprising. Saugeen Shore is the only host municipality around Bruce NPP although it is located at less than 20 km from the plant. It is also downwind of most frequent winds. It might then be contaminated in case of a massive radioactive release.

Regarding the Pickering NPP, Perbourough, the only designated host municipality, might have to shelter more than 100 000 persons. The capacity of the evacuee centres is not indicated. Would they be sufficient in case of accident?

6.5.3 Monitoring and decontamination

"The nuclear installation (except in the case of Fermi 2) is responsible for Monitoring and Decontamination, i.e., providing equipment and core staff, training staff, and performing the task (pursuant to federal licensing requirements to provide offsite assistance)" [EMO2009]. This is quite a chocking situation for evacuees who will not trust the operator's employees.

Regarding decontamination, the emergency response plan of Pickering specifies: *"given the population density, self-decontamination may be the primary means of decontamination, if required. [...] If conditions permit, evacuees will be advised (via an operational directive) to go to a facility for monitoring and decontamination. However, if that is not possible, evacuees should be advised to go to a destination of their own choice and once there, decontaminate themselves by bagging their old clothes, showering, washing their hair, and putting on a fresh change of clothes"* [EMO2009]. This might be very stressful for evacuees if they do not have access to monitoring after decontamination.

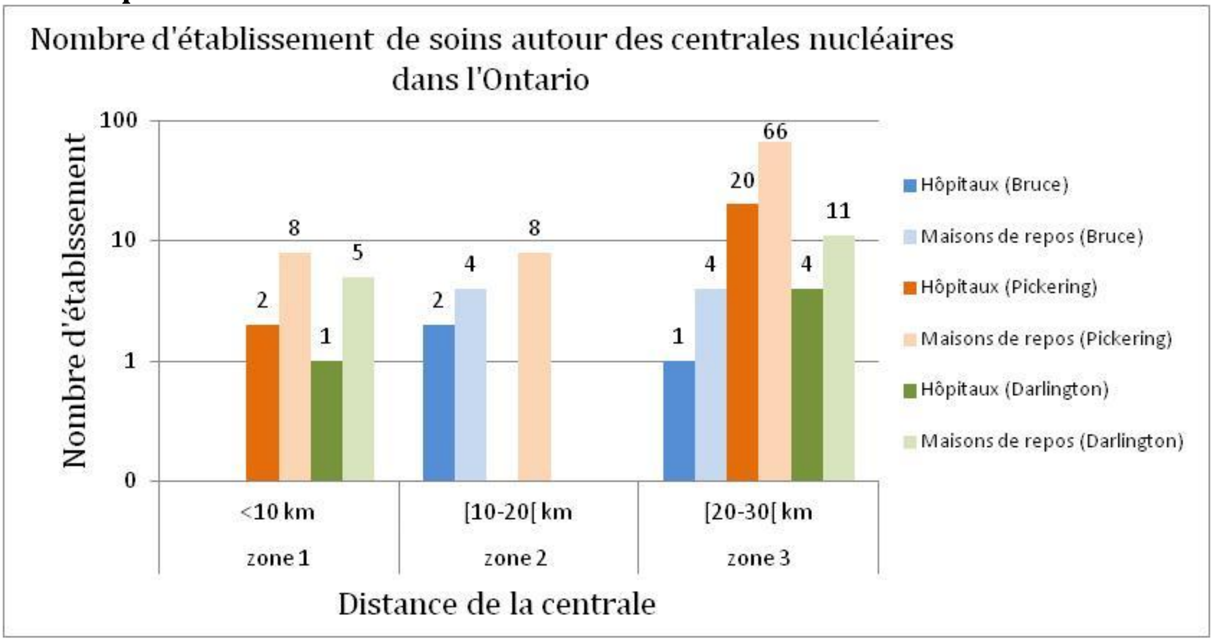
➔ **The operator should not be involved in the monitoring of evacuees. Its employees must focus on securing the nuclear power plant.**

6.5.4. Evacuation of vulnerable persons

Ontario Ministry of Health and Long term Care explains: *"this approach would involve specific population groups to be evacuated in anticipation of a general evacuation later, e.g., seriously ill patients in hospitals, bedridden residents of nursing homes, or residents/persons with disabilities [...]."* Thus, *"hospitals, nursing homes, long-term care facilities, and other health care facilities and organizations located in the Primary Zone of a nuclear facility must have plans in place for evacuation. Families of the residents should also be informed in advance of established arrangements"* [MHC2014b]. Such plans are not public.

Greenpeace Canada [GPC2015] has identified that within a 30 km radius of the Pickering Power Station there are no less than 22 hospitals with a total of 7 399 beds and 82 nursing homes with a total of 9 368 beds. For the Darlington station, there are 5 hospitals (1 040 beds) and 16 nursing homes (890 beds). Finally, around Bruce, there are 3 hospitals (61 beds) and 8 nursing homes (> 52 beds). See Figure 1.

Figure 1: Number of health care facilities and organizations located around nuclear power station in Ontario



However, emergency evacuation is not the best solution. It would be safer to remain in hospitals for a few days, before a smooth evacuation. This requires preparation such as isolating the buildings, preparing stocks, etc. This is the option that is now adopted in Japan. Is it being considered and prepared in Canada?

➔ **Vulnerable are at threat in case of nuclear emergency and requires special care. Immediate response cannot be evacuation. This should be well prepared.**

6.5.5. Evacuation time estimate

Evacuation time estimate of the primary zones of the Darlington and Pickering power stations is only available in the Durham Regional Plan provides. This study was commissioned by Ontario Power Generation, which operates both power plants. It gives an evacuation time, almost identical for the two power stations, of approximately 5 hours and 6.5 hours for the evacuation of the contiguous (3 km) and primary (10 km) zones respectively. Calculation assumptions are not presented. Were penalizing conditions taken into account?

The results of this assessment appear to be underestimated, particularly with respect to evacuation around the Pickering station, where the 10 km zone, including part of the City of Toronto, has approximately 250 000 inhabitants (almost twice of Darlington). The details of these estimates should be made public as is done in the United States, assessed by the authorities and discussed with the populations concerned.

In particular, has shadow evacuation being taken into account?

7. Foodstuff and Water

The most important issue for preventing or reducing the internal exposure of the residents in the medium to long term is how to prevent the ingestion of food contaminated with radioactive materials. Therefore, authorities should introduce food restrictions and shipping regulations.

7.1. International standards

International recommendations about concentration of radioelements in foodstuff are given in the Codex Alimentarus of the Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) [CODEX1995]. The Guideline Levels apply to radionuclides contained in foods destined for human consumption and traded internationally, which have been contaminated following a nuclear or radiological emergency. These guideline levels apply to food after reconstitution or as prepared for consumption, i.e., not to dried or concentrated foods, and are based on an intervention exemption level of 1 mSv in a year.

Let's only consider radioactive cesium and iodine for comparison.

The Guideline Level of the Codex Alimentarus for cesium is 1 000 Bq/kg for both infant and other foodstuffs. It is 100 Bq/kg for radioactive iodine, whatever the type of food.

European standards EURATOM n°3954/87 fixed after Chernobyl disaster with maximum permitted levels for radiocesium in foodstuffs of 1 000 Bq/kg for dairy products and 1 250 Bq/kg for other foodstuffs, except minor foodstuffs. It is 400 Bq/kg for baby food and 12 500 Bq/kg for less important food [SGDSN2014].

Japan, soon after Fukushima disaster, fixed these levels at 200 Bq/kg for diary products, baby food and 500 Bq/kg for other foodstuffs. New guidelines recommend adopting the same values in case of nuclear emergency [NRA2012]. These levels were decreased after few months in order to regain the confidence of consumers.

After the Fukushima disaster, Europe adopted Japanese standards for imported foodstuffs. It contrasts with the situation after Chernobyl disaster, when Belorussia decreased the maximum permitted levels, Europe didn't change its regulation. French guidelines specify that Euratom levels should be adopted within 24 hours after the disaster for a period no longer than 3 months. Europe will have the duty to define new maximum permitted levels within this period taking into consideration specificities of the accident [SGSDN2014].

In Europe and US, fixed maximum permitted levels are based on the assumption that 10% of the food consumed annually is contaminated. This is not realistic for populations living near the affected areas.

Table 3: Maximum permitted levels of radioactive contamination of food

		Baby food	Dairy products	Other food	Less important food
Iodine	**Codex**	100 Bq/kg			
	EU	150 Bq/kg	500 Bq/kg	2 000 Bq/kg	20 000 Bq/kg
	Japan	100 Bq/kg	300 Bq/kg	2 000 Bq/kg	
Cesium	**Codex**	1 000 Bq/kg			
	EU	400 Bq/kg	1 000 Bq/kg	1 250 Bq/kg	12 500 Bq/kg
	Japan	200 Bq/kg	200 Bq/kg	500 Bq/kg	

7.2. In Canada

Drinking water is particularly at risk in Canada as reactors are close to the lakes that provide drinking water to the population. In the Regional Municipality of Durham, for example, 110 940 out of 118 174 people directly depend on Lake Ontario water.

"Action levels for food and water are based on an intervention level of 1 millisievert (mSv) applied independently to each of three food groups, assuming that the intervention is completely effective at averting dose" [HC2000]. This potentially makes a total of 3 mSv.

"*In the derivation of action levels, it is assumed that contaminated foods comprise no more than 20% of an individual's annual intake of Other Commercial Foods and Beverages. The remainder consists of food unaffected by the emergency. For consumption of Fresh Liquid Milk and Public Drinking Water, which are generally drawn from local sources, it is assumed that the intake consists entirely of contaminated supplies"* [HC2000].

Thresholds for cesium-134 and 137, are 100 Bq/kg for public drinking water, 300 Bq/kg for fresh milk and 1 000 Bq/kg for other foods, beverages and drinking water. For iodine-131, it is the same level with the exception of fresh milk for which the threshold is lowered to 100 Bq/kg. Due to the Candu technology tritium is also considered. The thresholds are 30 000 Bq/kg for fresh milk and 100 000 Bq/kg for public drinking water and other food and beverages. These intervention thresholds are based on organically bound tritium for fresh milk and other commercial foods and beverages. Note that the determination of thresholds is well explained and justified in the Health Canada guidelines [HC2000]. Locally, the Ontario master plan sets a ban on consumption if the radioactive cesium concentration exceeds 1000 Bq/kg in food, milk and drinking water, which is not compatible with the federal guidelines. For iodine-131, it complies with federal limits. Surprisingly, there is no set level for tritium [EMO2009].

These guidelines assume that these thresholds are very low. However, an international comparison shows that this is not the case. Guidelines also state that *"some of these values may not be acceptable to the public given that background levels are significantly lower, other jurisdictions may have lower action levels for these classes of radionuclides, or the radionuclide may be of particular public concern, as is the case with ^{3}H (tritium) in drinking water resulting from routine reactor operating emissions.")* [HC2000]. It would be better to fix these levels before the accident.

Canadian consumers may not accept the limits set by the authorities and require the lowest limits found elsewhere. They might follow what happened in Japan where citizens rapidly cooperated to acquire detectors to control food contamination and set their own limits according to circumstances. Producers or supermarkets did the same [ACRO2012]. A rapid improvement was observed in Japan thanks to the large number of measurement stations and actors monitoring food. On the other hand, self-consumption can escape these controls.

➔ **Canadian authorities should adopt more stringent limits for the food and beuverage contamination that decrease with time. For the most exposed residents, the dose should be assessed globally.**

8. Emergency workers and helpers

8.1. International standards

Radioprotection of nuclear workers is well regulated even in case of an emergency. This is not the case for the many rescue workers and volunteers who might be exposed to radiations. ICRP note that emergency workers and their roles should be identified in advance. They should have appropriate training sufficient to carry out their emergency role, so that they have sufficient information upon which to base informed consent should that be needed, and so that they can contribute to their own protection. They should also be provided with personal protective equipment, and arrangements should be made to assess any radiation doses received. Considering those implementing early protective actions and taking action to protect the public, ICRP recommends that protection should be consistent with the full system for planned exposure situations where this is feasible [ICRP109].

IAEA guidelines on EP&R [IAEA2015] stipulate: *"the government shall ensure that arrangements are in place to protect emergency workers and to protect helpers in a nuclear or radiological emergency."* This includes arrangements:

- to ensure that emergency workers are, to the extent practicable, designated in advance and are fit for the intended duty;
- to register and to integrate into operations in an emergency response those emergency workers who were not designated as such in advance of a nuclear or radiological emergency and helpers in an emergency;
- to ensure that all practicable means are used to minimize exposures of emergency workers and helpers;
- to ensure that no emergency worker is subject to an exposure in an emergency that could give rise to an effective dose in excess of 50 mSv other than some specific cases such as the purposes of saving human life;
- to ensure that emergency workers who undertake emergency response actions in which doses received might exceed an effective dose of 50 mSv do so voluntarily.
- To ensure that helpers in an emergency shall not be allowed to take actions that could result in their receiving doses in excess of an effective dose of 50 mSv.

8.2. Lessons from Fukushima

According to a survey by an association of Fukushima Prefecture hospitals, conducted in late July 2011, hundreds of doctors and nurses have resigned from nearby facilities immediately after the accident. The survey found that 125 full-time doctors had resigned from 24 hospitals in the prefecture, or 12% of all doctors working at those institutions. As for nurses, 407 had quit from 42 hospitals in the prefecture, representing 5% of the nursing staff at those institutions. Their departures have resulted in some hospitals suspending night-time emergency care and other treatment services. The survey found that the highest number of doctors left from hospitals in Minami-Soma. Thirteen doctors resigned from four hospitals in the city, including one inside the exclusion zone. The figure represents 46% of the four institutions' total doctors. As for nurses, in Minami-Soma 44 left their jobs at four hospitals, or 16% of those institutions' total nursing staff. The association assumes most of the doctors and nurses who resigned did so due to their desire to leave the area amid concern about radiation exposure [GPI2012].

Japanese Nuclear Regulation Authority concludes that education to radiation protection and radiation emergency medicine for medical personnel and for students in curriculum or training course of medicine, nursing science and radiation technology should be promoted for better understanding and proper recognition of radiation emergency medicine [NRA2012].

8.3 In Ontario

Radiation Protection Regulations state: *"during the control of an emergency and the consequent immediate and urgent remedial work, [...] the effective dose shall not exceed 500 mSv"* [MJ2015]. According to the Canadian Nuclear Safety Commission, this dose limit could apply to workers onsite at the accident or to members of the public involved in the offsite response, such as first responders [CNSC2015b]. Such a limit is very high as it corresponds to the limit from which deterministic effects appear. The limit for offsite rescuers is fixed at 100 mSv in France and 250 mSv in Belgium [ACRO2015, ACRO2016a].

9. Terminating Emergency

At some time point emergency will end. When possible, returning to pre-emergency situation should be done in an open a transparent way, including stakeholders who might want to check on their own the situation. But is not always possible and long-term measures might include resettlement.

9.1. International standards

IAEA guidelines require that *"the government shall ensure that, as part of its emergency preparedness, arrangements are in place for the termination of a nuclear or radiological* *emergency. The arrangements shall take into account that the termination of an emergency might be at different times in different geographical areas"* [IAEA2015].

For a major accident resulting in the release of radioactive materials, some significant residual contamination of the environment may persist for a long period of time and continue to affect the population for decades. We cannot access some territories 30 years after the nuclear accident at Chernobyl. Food monitoring is still necessary on larger territories. In some parts of Norway, grazing animals are still treated with Prussian blue when they are in mountains in order to decrease the milk contamination within specified limits. ICRP recommends that the management of long-term exposures resulting from emergencies should be treated as an existing exposure situation [ICRP109 (113)].

ICRP adds: *"there are no predetermined temporal or geographical boundaries that delineate the transition from an emergency exposure situation to an existing exposure situation. In general, a reference level of the magnitude used in emergency exposure situations will not be acceptable as a long-term benchmark, as these exposure levels are generally unsustainable from social and political standpoints. As such, governments and/or regulatory authorities will, at some point, identify a new reference level for managing the existing exposure situation, typically at the lower end of the range recommended by the Commission of 1–20 mSv/year"* [ICPR109 (116)].

ICRP explains: *"national authorities may take into account the prevailing circumstances, and also take advantage of the timing of the overall rehabilitation programme to adopt intermediate reference levels to improve the situation progressively"* [ICRP111 (o)].

In contrast, U.S. guidelines require relocation when people may be exposed to 20 millisieverts or more of radiation in the first year and 5 millisieverts or below from the second year. The long-term objectives are to keep doses at or below 50 mSv in 50 years. The relocation protective action guide addresses post-plume external exposure to deposited radioactive materials and inhalation of re-suspended radioactive materials that were initially deposited on the ground or other surfaces [USEPA1992, FEMA2013].

Anand Grover, Special Rapporteur to UN Human Rights Council, notes: *"ICRP recommendations are based on the principle of optimisation and justification, according to which all actions of the Government should be based on maximizing good over harm. Such a risk-benefit analysis is not in consonance with the right to health framework, as it gives precedence to collective interests over individual rights. Under the right to health, the right of every individual has to be protected. Moreover, such decisions, which have a long-term impact on the physical and mental health of people, should be taken with their active, direct and effective participation."* He adds: *"As the possibility of adverse health effects exists in low-dose radiation, evacuees should be recommended to return only when the radiation dose has been reduced as far as possible and to levels below 1 mSv/year. In the meantime, the Government should continue providing financial support and subsidies to all evacuees so that they can make a voluntary decision to return to their homes or remain evacuated"* [HRC2013].

Transition should be democratically discussed with stakeholders and the civil society. IAEA guidelines on EP&R require that *"the termination of a nuclear or radiological* *emergency shall be based on a formal decision that is made public and shall include prior consultation with interested parties, as appropriate"* [IAEA2015]. People should also have the opportunity to choose whether they want to come back or not without any discrimination. As the European research group EURANOS explains, "*for some people, it may be preferable to stay away from the area until all decontamination measures have been carried out. For others, it may be more important to return home in the knowledge that some remedial work may be necessary at a later date. In this way the social and psychological needs of individuals can be met and excessive levels of stress avoided"* [EURANOS2008].

United Nations state that internally displaced persons (IDP) are persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, as a result of various causes including *"natural or human-made disasters, and who have not crossed an internationally recognized State border".* Evacuated persons from the contaminated places by the nuclear accident enter into this category and should benefit from the rights guaranteed by the Guiding Principles on Internal Displacement [UNESC1998].

Recalling that *"displacement nearly always generates conditions of severe hardship and suffering for the affected populations",* these Guiding Principles on Internal Displacement provide them guaranties. In particular, *"competent authorities have the primary duty and responsibility to establish conditions, as well as provide the means, which allow internally displaced persons to return voluntarily, in safety and with dignity, to their homes or places of habitual residence, or to resettle voluntarily in another part of the country. Such authorities shall endeavour to facilitate the reintegration of returned or resettled internally displaced persons."* They add that *"internally displaced persons have the right to be protected against forcible return to or resettlement in any place where their life, safety, liberty and/or health would be at risk"* and that *"special efforts should be made to ensure the full participation of internally displaced persons in the planning and management of their return or resettlement and reintegration"* [UNESC1998]. This is definitively not the case in Japan, leading to a lot of suffering of displaced persons [ACRO2016b].

France has published Policy Elements for Post-Accident Management in The Event of Nuclear Accident [CODIRPA2012]. It is currently limited to a small-scale accident, but new policy for severe accidents in under preparation.

The Belgian Superior Health Council recently recommended implementing a CODIRPA-like plan in Belgium as promptly as possible in 2016 [CSS2016].

9.2. Lessons from Fukushima

Presently, Japan has no calendar for such a transition. The return policy of the population in evacuated zones is still based on an annual limit of 20 mSv. Population, especially with young children, are reluctant to go back to their home. Actually, if the return level were fixed to a lower value, non-evacuated people would not understand and feel abandoned [ACRO2016b]. Internally displaced persons are not invited to participate in the planning and management of their return or resettlement and reintegration. This leads to a lot of suffering of displaced persons [ACRO2016b].

9.3. In Ontario

The provincial master plan specifies: "*the recovery phase is when action is required to restore conditions to normal*" [EMO2009]. But after a severe accident, there is no return to normal conditions.

At the Federal level, it is stipulated: "*once the situation has stabilized and immediate and other actions for the protection of public health and safety have been completed, emergency management of the radiological hazard will shift from the response phase to recovery. […] Responsibility for recovery is largely within provincial/territorial jurisdiction.*" Moreover, "*it is important to identify early in the event potential issues that will need to be addressed during the long-term recovery after an emergency. Preparedness activities will include the development of a basic framework recovery plan to address common issues to facilitate the transition to recovery operations*" [HC2014]. This is not realistic. How to manage emergency and prepare for recovery at the same time? Recovery should be prepared before the accident.

Canadian guidelines stipulate: "*seven days is taken to be the longest time that people can be lodged in temporary accommodations. People would be allowed to return to their homes if the dose avertable by a continued evacuation were less than 10 mSv per month*" [HC-SC2003]. "*However, if conditions prevented return after a week, or a reassessment of the situation indicated persistent high levels of radioactivity, the countermeasure would be converted to a longer-term relocation […]. Relocation involves moving people and belongings from their homes, or from emergency evacuation centres, to live in alternate accommodations for a period of several weeks to one year, with the expectation of being able to return to their homes in due course. If times longer than a year are indicated, then permanent resettlement would need to be considered […]. Relocation should be considered if the action will avert a dose of at least 50 mSv for a period of up to one year following the time of the assessment […] The relocation may be discontinued when the avertable dose falls below 50 mSv/year and 10 mSv/month (the same level as for ending a short-term evacuation)*" [HC2003].

These dose limits are too high with respect to ICRP's recommendations. In Japan many, especially families with young children, considered a limit fixed at 20 mSv per year for relocation as too high [ACRO2016b].

As a matter of facts, the Canadian Nuclear Safety Commission also notes: "*federal and provincial nuclear emergency planning authorities do not fully address recovery phase guidelines and procedures in their emergency plans, as they primarily address only preparedness and response*" [CNSC2011]. This is still true.

- ➔ **Canada should have a post-accidental policy to face long-term consequences of a nuclear disaster. This plan should be defined with stakeholders.**

10. Engagement with stakeholders

11.1. International standards

During emergency there is no time to discuss with the stakeholders about the measures decided to protect the populations. This should be done before as recommended by ICRP: *"During planning, it is essential that the plan is discussed, to the extent practicable, with relevant stakeholders, including other authorities, responders, the public, etc. Otherwise, it will be difficult to implement the plan effectively during the response. The overall protection strategy and its constituent individual protective measures should have been worked through with all those potentially exposed or affected, so that time and resources do not need to be expended during the emergency exposure situation itself in persuading people that this is the optimum response. Such engagement will assist the emergency plans by not being focused solely on the protection of those at greatest risk early in an emergency exposure situation"* [ICRP109 (54)].

IAEA guidelines on EP&R also state: *"the government shall ensure that interested parties are involved and are consulted, as appropriate, in the development of the protection strategy"* [IAEA2015].

We cannot overemphasize that the main goal of consulting the stakeholder in general and the civil society in particular is to adapt emergency response plans to their needs and constrains. European EURANOS group also stresses that *"stakeholders need to be involved at the planning stage to help determine appropriate reference levels for emergency exposure situations and trigger levels for the implementation of emergency countermeasures"* [EURANOS2008].

10.2. In Ontario

The Canadian Nuclear Safety Commission notes: *"there is no formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance. Whereas NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process, there is no similar system of oversight for offsite emergency plans"* [CNSC2011]. It also notes that *"there are ongoing public alerting issues in the 3 km zone around the Pickering NPP. Also, the new 10 km public alerting requirement has not been fully implemented"* [CNSC2011].

Therefore CNSC recommends: *"federal and provincial nuclear emergency planning could be strengthened through establishing a formal, transparent, national-level oversight process for offsite nuclear emergency plans, programs and performance, and through scheduling of regularly planned full-scale exercises"* [CNSC2011]. Such an assessment should be done with stakeholders.

Several Canadian environmental organisations such as CELA or Greenpeace are calling for nuclear emergency plans to be discussed with the affected population and stakeholders [CELA2013]. In Europe, Nuclear Transparency Watch also stresses that *"the usual top-down approach doesn't work. This approach, which has been used to date in EP&R, should be changed and should involved local communities and interested civil society organisations to take an action to improve the situation"* [NTW2015].

11. Conclusions

Ontario is not ready to face a severe nuclear accident and the population surrounding nuclear power stations are at risk. The large number of inhabitants will hamper protective response actions. Consequently, Canadian authorities keep lax protective action levels. Using more stringent levels would mean to extend the protection zone that would include a too large number of persons. In agreement with IAEA's recommendations, the CCSN explains that emergency plans are aimed *"to prevent the occurrence of deterministic health effects in workers and the public"* and *"to prevent, to the extent practicable, the occurrence of stochastic health effects in the population"* [CCSN2014]. Health Canada Guidelines specify that deterministic effects *"generally do not occur below a certain dose threshold, typically 500 mSv or more"* [SC2003]. Note that above 200 mSv the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) does not consider it as "low doses" anymore.

Canadian authorities should provide a better protection against radiations.

In Japan, "*as to the possibility for radiation exposure, [populations] were only told that there was no immediate health impact. The survey revealed that this was the cause of numerous problems and concerns, including a belated evacuation that caused residents to undergo unnecessary radiation exposure"* [NAIIC2012].

The new Japanese Nuclear Regulation Authority writes in its interim report on emergency preparedness [NRA2012]: *"One of the lessons learned from the accident at the Fukushima Dai-ichi Nuclear Power Plant is that the arrangements for emergency preparedness for the nuclear power plants were not adequate, because it had been assumed that "severe accidents will not happen actually" as in the case of past nuclear or radiological emergencies. The Emergency Preparedness Guide was issued in 1980 after the nuclear power plant accident at Three Miles Island (TMI) in the USA. Subsequently several revisions were made based on experience of domestic or overseas accidents and international considerations. However, since the occurrence of such an accident at the Chernobyl nuclear power plant in the former Soviet Union was considered to be hardly conceivable, the Emergency Preparedness Guide does not adequately address any severe accidents which practically require protective measures outside nuclear power plant sites.*
[…]
As shown in the accident at the Fukushima Dai-ichi Nuclear Power Plant, a nuclear power plant has a potential hazard resulting in a severe accident. The operator, relevant ministries and agencies, and local governments should realize the potential risk of nuclear power plants and perform arrangements for preparedness and response for a nuclear or radiological emergency."
The same remarks apply to the Canadian situation.

Canadian authorities should openly acknowledge that a severe nuclear accident could happen in Ontario like in any other country and trigger a complete reorganisation of EP&R to cope with such a possibility. New response plans should be defined with the involvement of stakeholders.

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