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Response systems to risks and accidents of nuclear power plants

Challenges of the early phase after an accident

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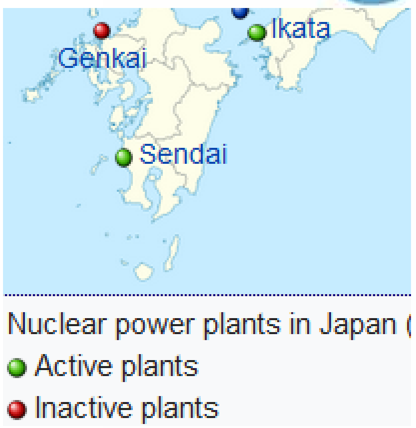
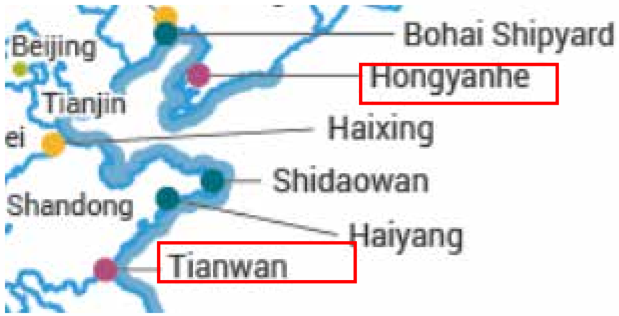
Overview

- The nuclear reactors in South Korea and neighboring countries
- Response systems to nuclear accident: a border-crossing issue
- Causes of nuclear accidents and radiological release scenarios
- Phases of response and measures
- Past experiences and communication challenges
- Multifunctional response systems
- Conclusions

Nuclear Reactors
South Korea and neighbouring regions of China

- South Korea
  - 24 reactors providing about 30% of its electricity demand
  - Net capacity 22,505 MWe
- Neighbouring regions in China
  - Tianwan 1&2 net capacity 990 MWe each
  - Hongyanhe 1-4 net capacity 1061 MWe each
  - Distance to Seoul about 480 km
- Neighbouring regions in Japan
  - Sendai 1&2 restarted in 2015, net capacity 846 MWe each
  - Ikata 3 restarted in 2016, net capacity 836 MWe
  - Distance Busan – Sendai about 370 km





Nuclear power plants in China

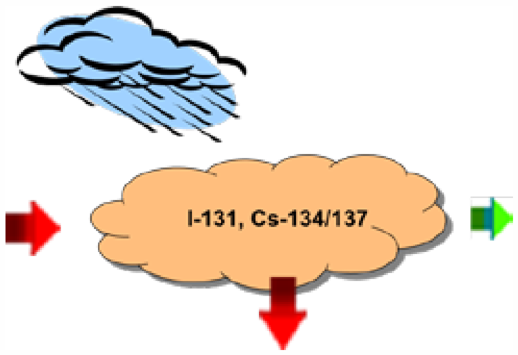
Source: World Nuclear Association/Wikipedia 2017, adapted by author

The task of response systems to nuclear accident: border crossing issue

- The consequence of a nuclear accident is the release of radionuclides into the environment (soil, water and air) with negative effects to health of human but also of other living organisms.
- The nuclear accident occurs suddenly and the consequent release processes, mainly via air, are very fast and hardly predictable.
- These consequences are *long term and far reaching and border-crossing*
- Responding to a nuclear accident requires radiation protection measures
  - to reduce the health and other effects caused by already occurred radionuclide releases,
  - to estimate and to reduce the risk of further releases of radionuclides from the facility.
- The response systems must be extraordinary well developed in advance and should also involve efficient transboundary communication and help.

Causes of nuclear accidents and release scenarios

- Natural catastrophe – Earthquake/Tsunami (e.g. Fukushima/Japan)
- Accident in the course of technical defects and human errors (e.g. Three Mile Island/USA, Chernobyl/Soviet Union, Chalk River/Canada)
- Accident in the course of a conflict (e.g. bombardement of nuclear reactor Osirak/Iraq, no fuels in reactor - no radioation release)
- Worst case scenario of explosion with far reaching fall- and washout (Fukushima, Chernobyl)
  - depends on inventory, explosion strength and athmospheric conditions
  - release mainly of noble gases, Iodine-131, Caesium 137/134
- Worst case scenario of core meltdown
  - several radionuclides released
  - high contamination of groundwater, soil, sea (above mentioned cases)



Phases of response to a nuclear accident

- Early phase: response measures to happen very fast but limited information regarding accident condition and limited time for analyzing options
  - Atmospheric modeling and radiation monitoring and analysis
  - Protective actions
  - Population monitoring
  - Medical planning and response
  - Biodosimetry
- Intermediate and late phase: more time to plan the response and to analyze the options
  - Planning follow-up and health risk studies regarding exposed populations and workers
  - Transition to recovery

Early phase: response measures (1)

- Atmospheric modeling and radiation monitoring and analysis
  - information/data about the nuclear reactor status and relevant inventories, atmospheric data and weather prognosis, aerial and ground/sea based monitoring of large areas

- Protective actions - options: evacuations (psychosocial and socioeconomic effects) versus sheltering in place, decision must consider sensitive populations (fetuses/children)
  - Evacuation in advance if safely practicable: preferable from areas at risk of high contami-nation, questionable in areas with dense population and large cities (*emergency plan*)
  - Sheltering-in-place (intake ventilation off, windows closed) to avoid the radioactive plume
  - Immediate medical countermeasures (Potassium Iodide)
  - Identification/interdiction of contaminated or potentially contaminated food and delivery of non (or low) contaminated food and *drinking water*
  - *Dose limits for emergency situation – should be fixed in advance (workers and population, recommendations of International Commission for Radiation Protection ICRP)*

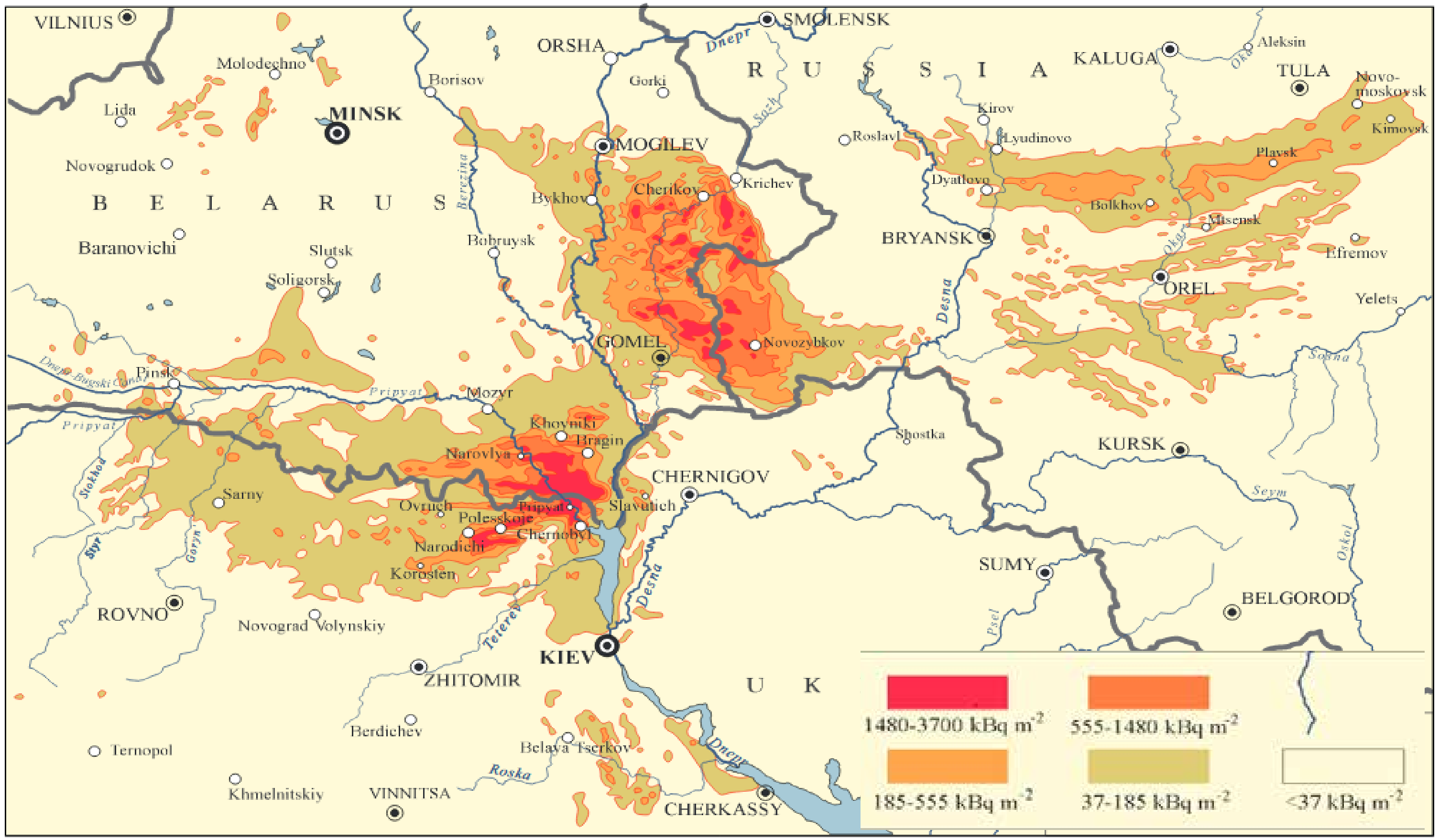
Early phase: response measures (2)

- Population monitoring for preventing radiation effects includes mainly
    - People needing immediate medical attention irrespective if exposed to radiation or not.
    - People who have been exposed (or who think that they have been exposed) to radiation or radioactive materials.
- Medical planning and response
    - Chernobyl and Fukushima showed the indispensability of well developed medical preparedness and response in case of nuclear accidents.
    - This has to involve activities including bioassays and other methods with the aim to
        - reassure people that they are not at risk,
        - provide medical care as regard acute radiation syndrome casualties.
- Biodosimetry: diagnostic to identify the radiation exposure and involving distribution of detection devices for workers and population.

Contamination release fall/wash-out
Past experiences with accident INES 7 Chernobyl

Chernobyl (Chernobyl 4, net capacity 925 MWe)

- Very far reaching but evacuation over large areas possible
- Chernobyl – Tula about 600 km
- Chernobyl – Cherykow about 270 km

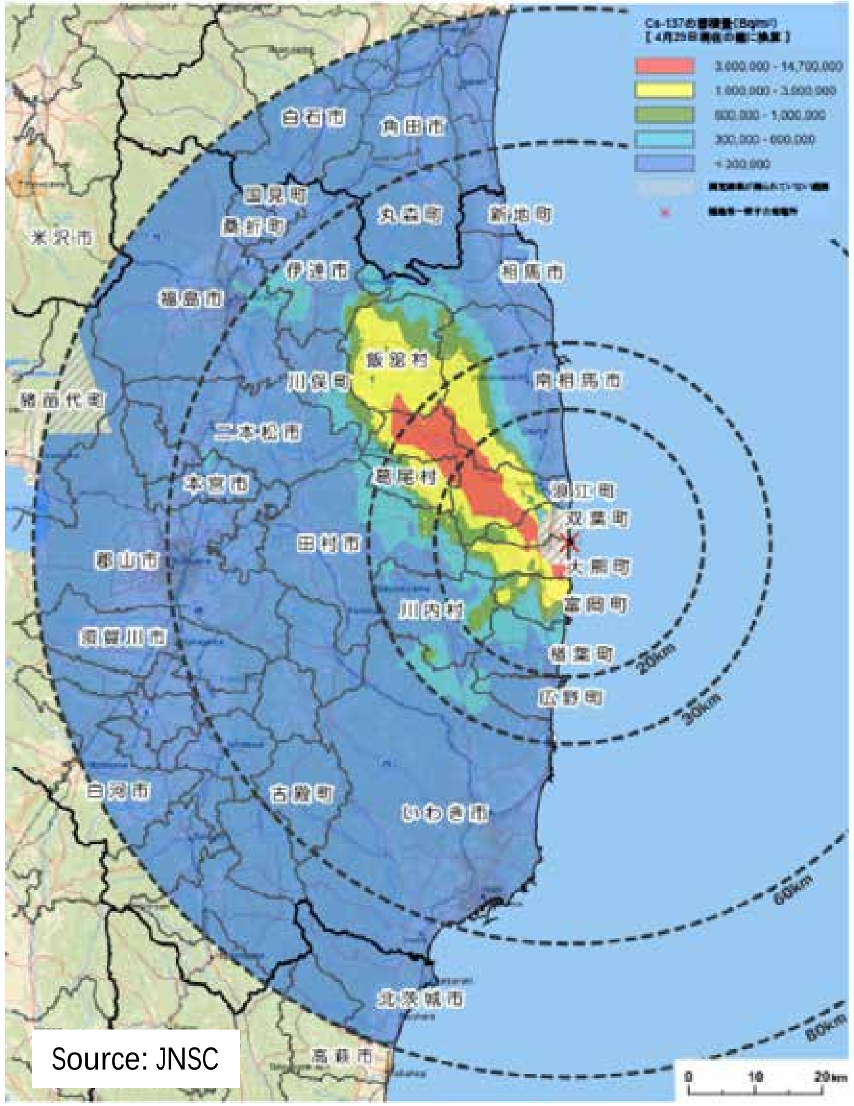


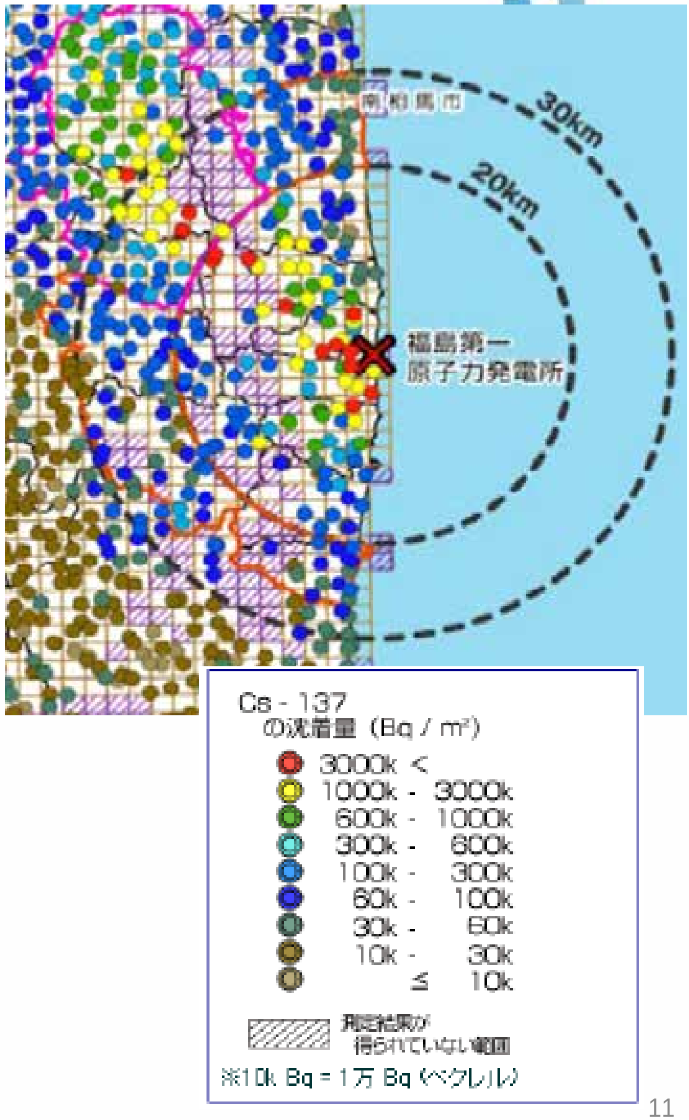
Source: UNSCEAR Surface ground deposition of caesium-137 released in the Chernobyl accident

Contamination release fall/wash-out
Past experiences with accident INES 7 Fukushima

Fukushima

- In 30 km downdraft
  > 3,000,000 Bq/m² Cs-137 measured
- The advantageous wind direction prevented further contamination of large areas but limited areas for evacuation available.





Past Experience
Challenge of risk perception and communication

- Radiation is invisible, most people are unfamiliar with the issue.
- Radiation is seen as representing special danger to children and pregnant women.
- Radiation is associated with cancer and death and other negative health unknown effects.
- The threat seems to be unbounded or open-ended.
- The people fear the potential for long-term contamination and that it causes hidden damage.
- People evacuated from contaminated areas are stigmatized.
- The clear communication and information with promoting confidence are crucial 1) in advance, 2) in the course of and 3) after an accident.

Response systems (beyond the desaster emergency response)

- Involve emergency and evacuation plan to be developed in advance (extent dependence).
- Must be adaptable to continuously changing conditions.
- Clear responsibilities of institutions and their staff (state/local-city) in decision making and efficient communication structure; system of information exchange between responsible institutions but also border-crossing crucial.
- Establishment of dedicated (emergency) technical staff on site and at supporting institutions also providing periodic updates to state and local officials.
- Fast development of technical solutions on site; international cooperation essential.
- System assuring to gather and to provide information on the nuclear reactor status and release inventories, radiation monitoring, modelling etc…
- System assuring biodosimetry and system of medical centers.
- Communication to public in advance and by nuclear accident, e.g. call centers (confidence!)
- System of drinking water and nutrients supply (fixed contamination limits).

Conclusions

- The severe nuclear accidents are border-crossing and long term and are possible in every operating reactor worldwide.
- To be well prepared: emergency and evacuation plan with optimizing procedure according to several scenarios must be developed in advance, in coordination with desaster emergency response but radiation protection requires specific response measures.
- Effective response systems require technical and scientific international cooperation.
- No financial limits.
- Communication with public is crucial.
- The best option is: accident never occurs but the reality is different.

Thank you for your attention!

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