Probabilistic Off-site Consequences Analysis

towards a ‘guidance document’ for Nordic Nuclear Power Plants

VATTENFALL

Probabilistic assessment of off-site consequences from accidental radioactive release from a NPP (L3PSA), aim to estimate and assess the radiological risks after a hypothetical nuclear accident, preferably in a way that make it possible to compare these risks with other risks in society. Typical output are health effects, economic impacts or environmental damages.
This project, a cooperation within the Nordic Nuclear Safety Research program NKS, focuses on 1) additional insights gained from a L3PSA (compared to a Level 2 PSA), 2) key uncertainties in L3PSA studies and 3) investigating proposed risk metrics. The project contains two pilot studies; one Swedish and one Finnish, and a final guidance document will be developed.

Safety goal to be achieved

Generally
Current regulatory framework for long term consequence assessments is largely based on criteria on Cs release in both Sweden and Finland.

L3PSA
Not required for operating NPP’s in Sweden or Finland.
Aim – should be possible to compare results with other societal risks.
General accidental death risk of an individual is on the level of about 1E-4 per year. In SSM-Rapport-2010-35 it is suggested that the safety goal for PSA L3 could be1/100 times lower, ie 1e-6.

Swedish Pilot

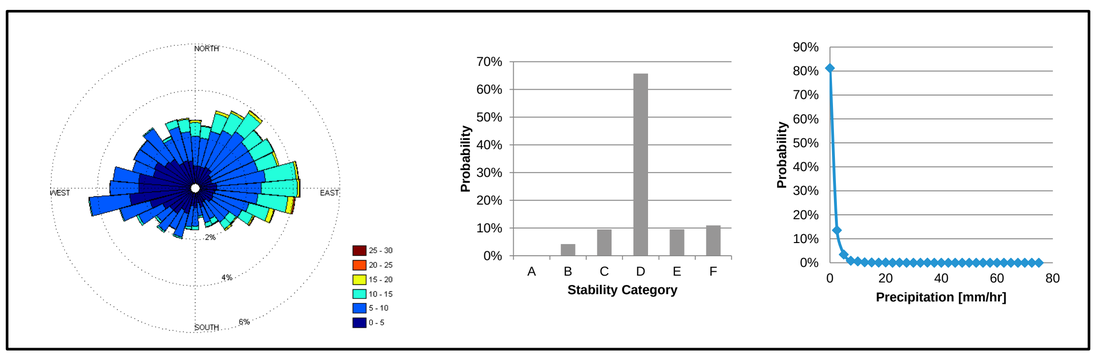
Suggested risk metrics in this pilot seek to provide an overview of the key probabilistic consequence analysis combinations.

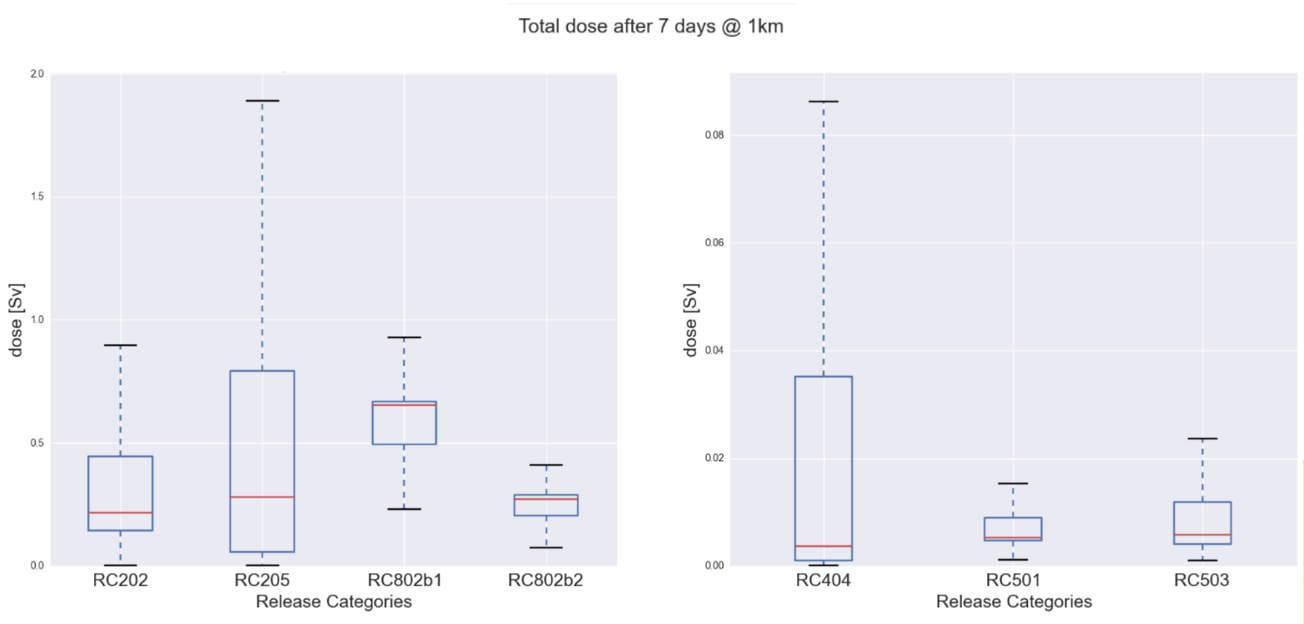
Table 2: Analysis cases for the evaluation of Level 3 PSA specific risk measures

	Metrics	Health				Environment	Economic
Analysis Characteristics	Risk Measure/ Assumption	Maximum individual dose at 1 km (early effects)	Risk of (early) death to max-imum exposed individual	Collective Dose (late effects)	Number of Latent Cancers (late effects)	Size of land area with significant Cs contami-nation	Estimate of value of lost land due to Cs contamination
Analysis Area	Up to 50 km	X	X	X	X	X	X
	Up to 100 km	-	-	X	X	X	X
Countermeasures	5 km eva-cuation zone	X	X	-	-	-	-
Cs‡ ground con-tamination thres-hold	1000† kBq/m^2	-	-	-	-	X	X
	100† kBq/m^2	-	-	-	-	X	X

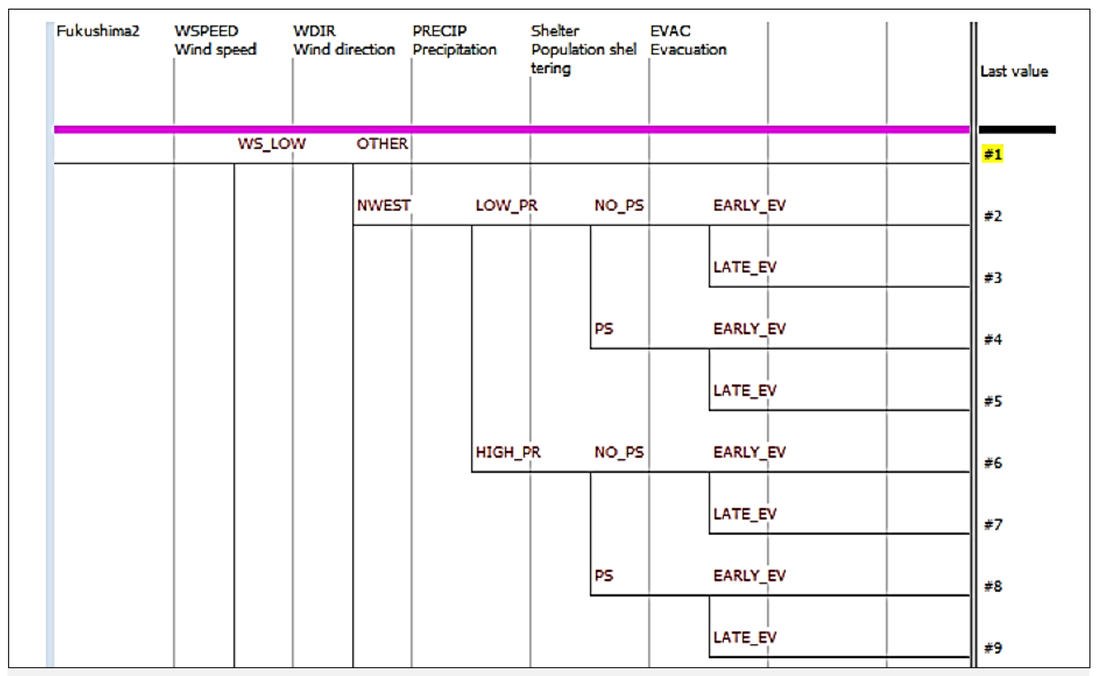
†: Cs ground contamination thresholds may need some iteration once radioactivity contour maps have been produced.
‡: Combined activity of ^{134}Cs and ^{137}Cs.

- ❑ Source term – EPR RC with Cs-release fractions above/below ‘acceptable’ releases, early and late release
- ❑ Dispersion model – straight line Gaussian distribution LENA
- ❑ Dose model – cloud-shine, inhalation and ground-shine
- ❑ Population distribution – radial sectors (post-processing data)





Finnish Pilot



ref. vtt-R-05661-14

Fukushima – What would the consequences be if no earthquake?

- ❑ Source term - Fukushima acc. UNSCEAR 2013, 3 h release
- ❑ Atmospheric dispersion model - a straight line dispersion, ARANO
- ❑ Population distribution – bigger cities

Uncertainties analysis –wind speed and direction probabilities, probability of rain, population sheltering and the portion of the dose the population is exposed to when sheltered.

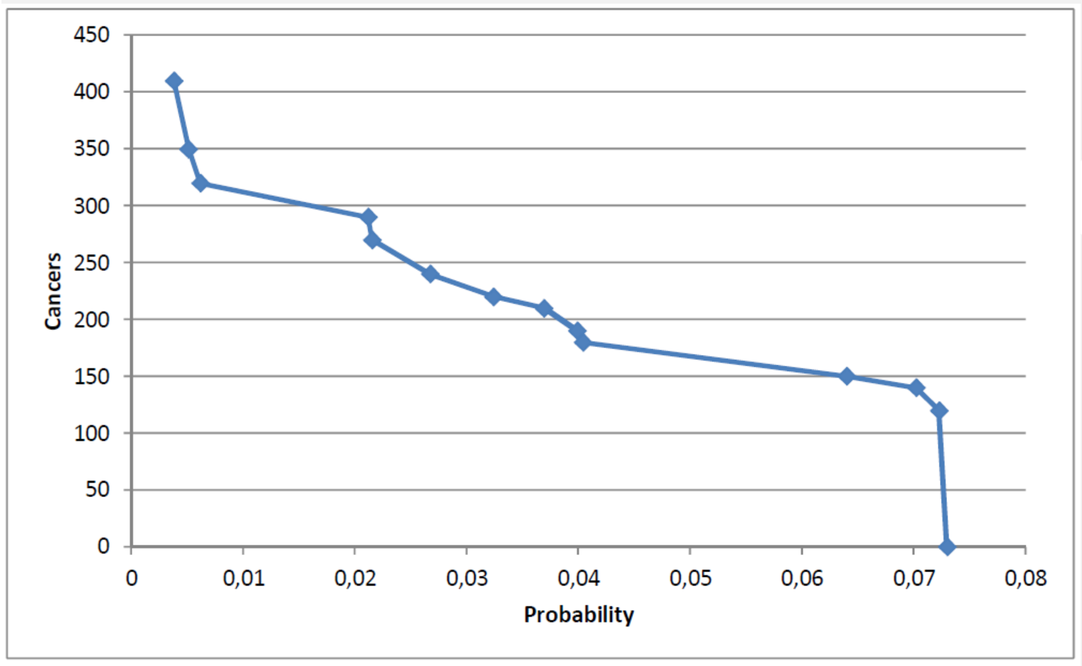


Figure 1: Farmer's curve.

- ❑ With a probability of 0,927 there will be no cancer deaths
- ❑ Worst conditions give 410 cancer deaths
- ❑ Expectation value is 16 cancer deaths
- ❑ Uncertainty analysis (10 000 simulations) → expected # lethal cancers is between 10 and 20 with a probability of 0,95.

Summary

1) Additional insight from a L3 is gained, connected with uncertainties.
2) Key uncertainties – evacuation success, ‘weather’, etc
3) Key risk metrics are proposed and will be further investigated

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