FENNOVOIMA

Maritime oil spill risk assessment for Hanhikivi nuclear power plant

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Background

- Fennovoima is planning to build a new nuclear power plant (Hanhikivi 1) on a new site in Northern Finland
  - AES-2006 PWR plant supplied by Russian Rosatom
  - Scheduled start of commercial operation in 2024

- Maritime oil spill accident is one of the risks to be considered in the plant PRA
  - Heavy oil products could clog the sea water intake screens

Method

- The assessment of oil risk for Hanhikivi 1 includes the following evaluations:
  1. Frequency of a nearby oil spill accident (≥ 100 tonnes)
  2. Oil spill behaviour and movement
  3. Probability of a duly oil spill warning
  4. Probability of successful oil combat

- Event tree analysis is used to determine the probability that at least 1 tonne of oil enters the sea water tunnel
  - Two cases: medium spill 100-1000 t and large spill > 1000 t

Bothnian Bay - transports and traffic

- Hanhikivi site is located in the Bothnian Bay in the northern Baltic Sea
- Bothnian Bay sea transports
  - No crude oil and no significant amounts of other oil products
  - About 2 % of the sea transports (and accidents) in the Baltic Sea take place in the Bothnian Bay

Baltic Sea

Bothnian Bay

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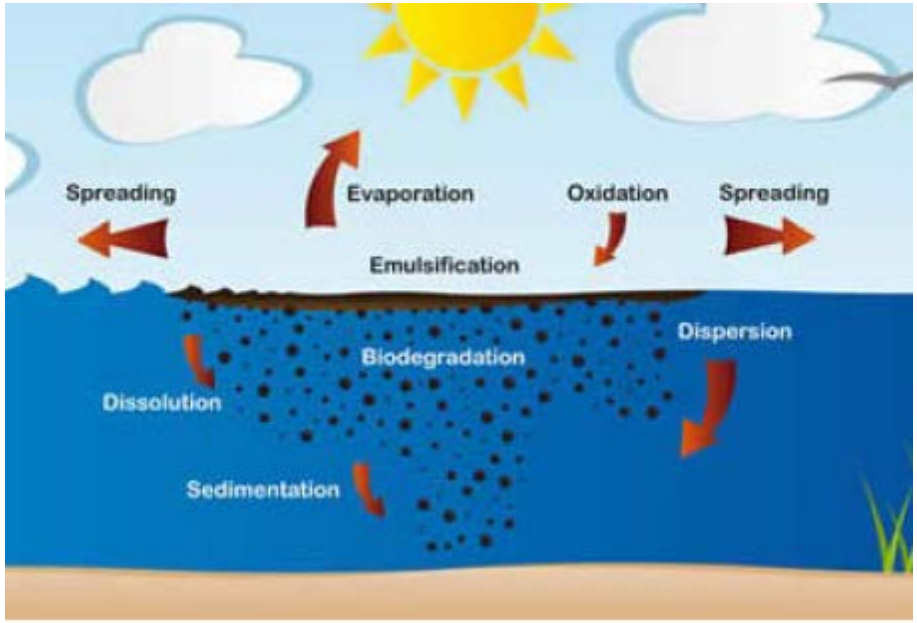
Baltic Sea - accidents

- 27 significant oil spills in the Baltic Sea in 1969-2011
  - Max 16 000 t, mean 1500 t, median 300 t

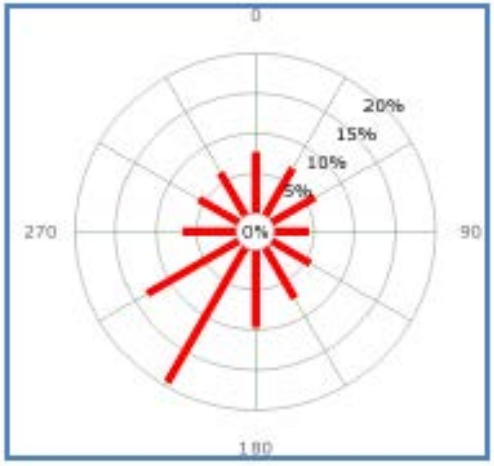
Year, ship name, location and spill size (tonnes)			
1969, Raphael, Finland (Emäsalo)	250	1990, Volgoneft, Sweden (Karlskrona)	1000
1969, Palva, Finland (Utö)	200	1992, Unknown, Sweden (Västra Götaland and Halland)	200
1970, Esso Nordica, Finland (Pellinki)	600	1993, Kihnu, Estonia (Kopli Peninsula)	100
1970, Pensa, Finland (Hailuoto)	500	1995, Hual Trooper, Sweden (Öresund)	180
1977, Tsesis, Sweden (Stockholm)	1000	1998, Weston, Sweden (Västra Götaland)	4000
1979, Antonio Gramsci, Finland (Åland)	5500	1998, Pallas, Germany (Wadden Sea)	244
1979, Lloyd Bage, Finland (Harmaja)	100	1998, Nunki, Denmark (Kalundborg fjord)	100
1981, Globe Asimi, Lithuania (Klaipeda)	16000	2000, Alambra, Estonia (Muuga)	250
1984, Eira, Finland (Merenkurkku)	300	2001, North Pacific, Lithuania (Klaipeda)	3427
1985, Sotka, Finland (Märket)	370	2001, Baltic Carrier, Denmark (Kadetrenden)	2700
1987, Antonio Gramsci, Finland (Vaarlahti)	650	2003, Fu Shan Hai, Sweden (Ystad)	1200
1987, Tolmiros, Sweden (Västra Götaland)	400	2004, Herakles, Sweden (Grundkallen)	200
1987, Thuntank 5, Sweden (Bay of Gävle)	230	2006, Runner 4, (Gulf of Finland)	100
1988, Unknown, Sweden (Torekov)	287		

Oil spill behaviour

- After oil is spilled on the sea, several processes begin



- Spill movement
  - General formula:
    Oil spill speed ≈ 3% · Wind speed + 100% · Sea current speed
  - In typical Bothnian Bay conditions:
    to NE, speed 30 cm/s = 1,1 km/h = 26 km/day



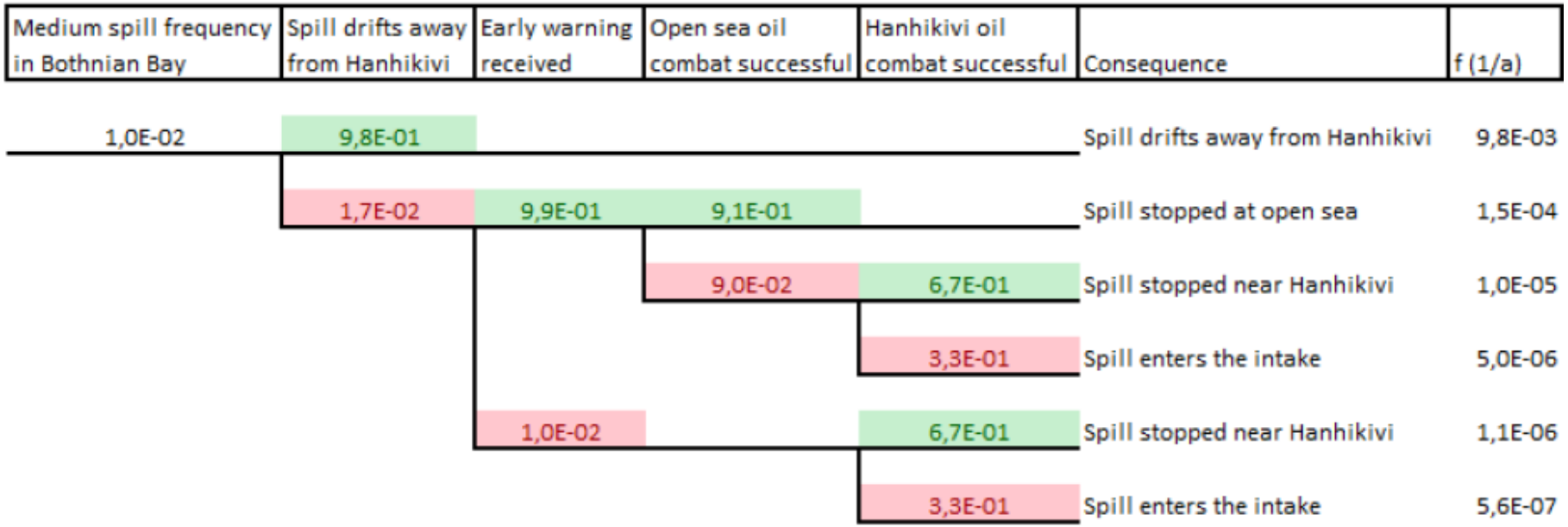
Oil combat

- Open sea: Oil spill is surrounded by booms and collected with skimmers
- Hanhikivi: Protection of sea water intake with booms

- The success of oil combat depends mostly on
  - Duly oil spill warning
  - Weather and sea conditions

- Oil combat preparedness in Finland:
  - Oil combat stations, multifunctional oil spill response ships, oil combat boats
  - Oil collection: 5000 tonnes during 3 days (slower in winter)
  - Oil boom deploying: 2 km in 12 h, 80-90 km in 72 h

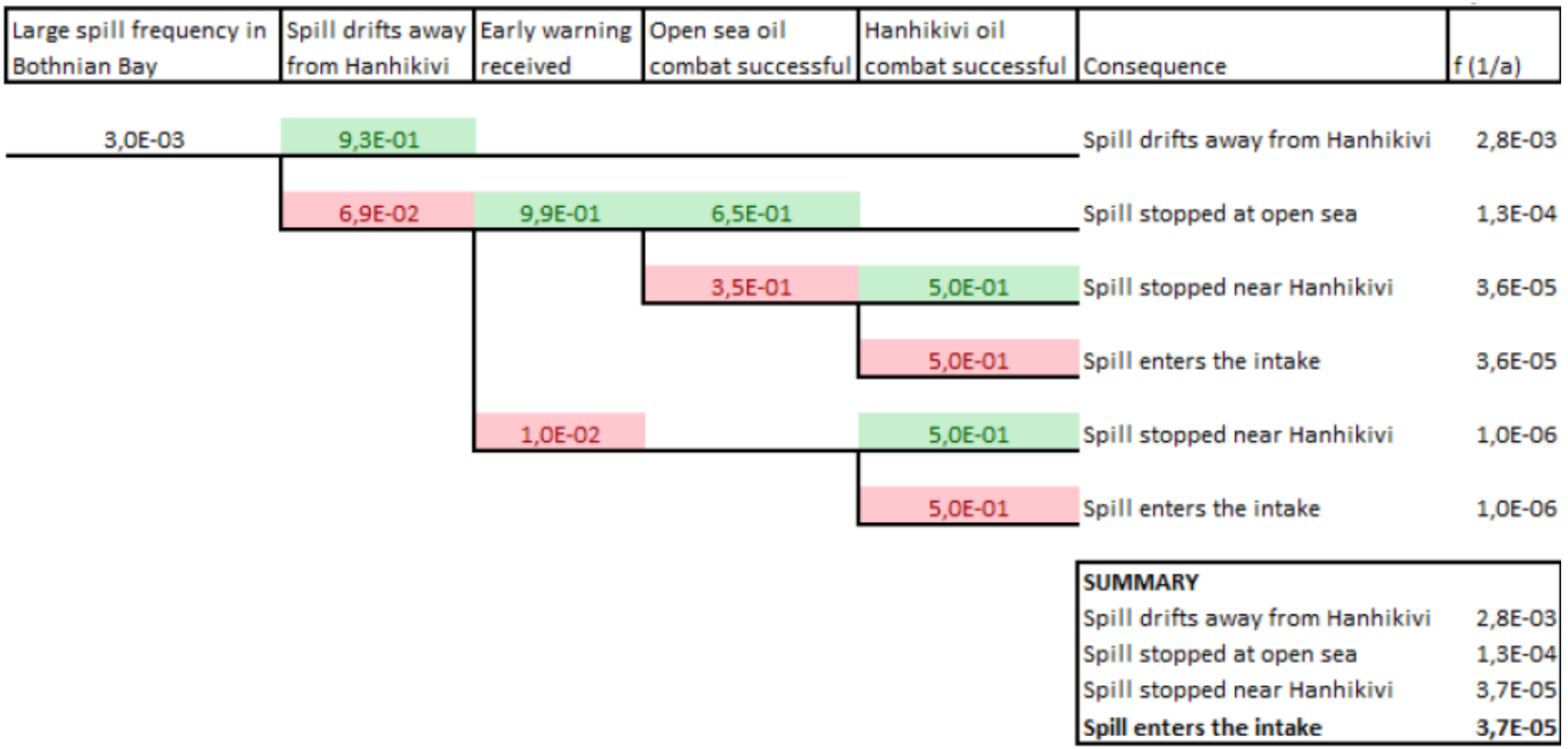
Results, medium spill (100-1000 t)



SUMMARY	
Spill drifts away from Hanhikivi	9,8E-03
Spill stopped at open sea	1,5E-04
Spill stopped near Hanhikivi	1,1E-05
Spill enters the intake	**5,6E-06**

- Medium spill frequency $1{,}0 \cdot 10^{-2}$/a
  - Significant amount of oil reaches the plant intake with a 0,06 % probability: frequency $5{,}6 \cdot 10^{-6}$/a

Results, large spill (> 1000 t)



SUMMARY	
Spill drifts away from Hanhikivi	2,8E-03
Spill stopped at open sea	1,3E-04
Spill stopped near Hanhikivi	3,7E-05
Spill enters the intake	**3,7E-05**

- Medium spill frequency $3{,}0 \cdot 10^{-3}$/a
  - Significant amount of oil reaches the plant intake with a 1,2 % probability: frequency $3{,}7 \cdot 10^{-5}$/a

Uncertainties

- Sensitivity analysis
  - Largest uncertainties related to oil spill frequency estimation, and oil spill behaviour
  - By using different assumptions, the annual probability varies between $9{,}8 \cdot 10^{-6}$ … $2{,}3 \cdot 10^{-4}$ (best-estimate $4{,}2 \cdot 10^{-5}$)

- Possibilities for more detailed analysis
  - Small spills < 100 t, distant accidents, coastal oil leaks
  - Simulation of oil spill behaviour and movement
  - Detailed types of oil products transported in the Bothnian Bay
  - Oil spill behaviour and oil combat in wintertime
  - Oil effects on the power plant

Summary and conclusion

- Significant amount of oil enters the plant intake due to nearby oil accident with an annual probability $4{,}2 \cdot 10^{-5}$
- The oil risk for the Hanhikivi plant can be considered small
  - The oil product transport volumes are small and no crude oil is transported near Hanhikivi
  - Residual heat can be removed also if the primary heat sink (sea) is lost

End of presentation, questions?