Radiation health effects and nuclear accident consequences – an overview

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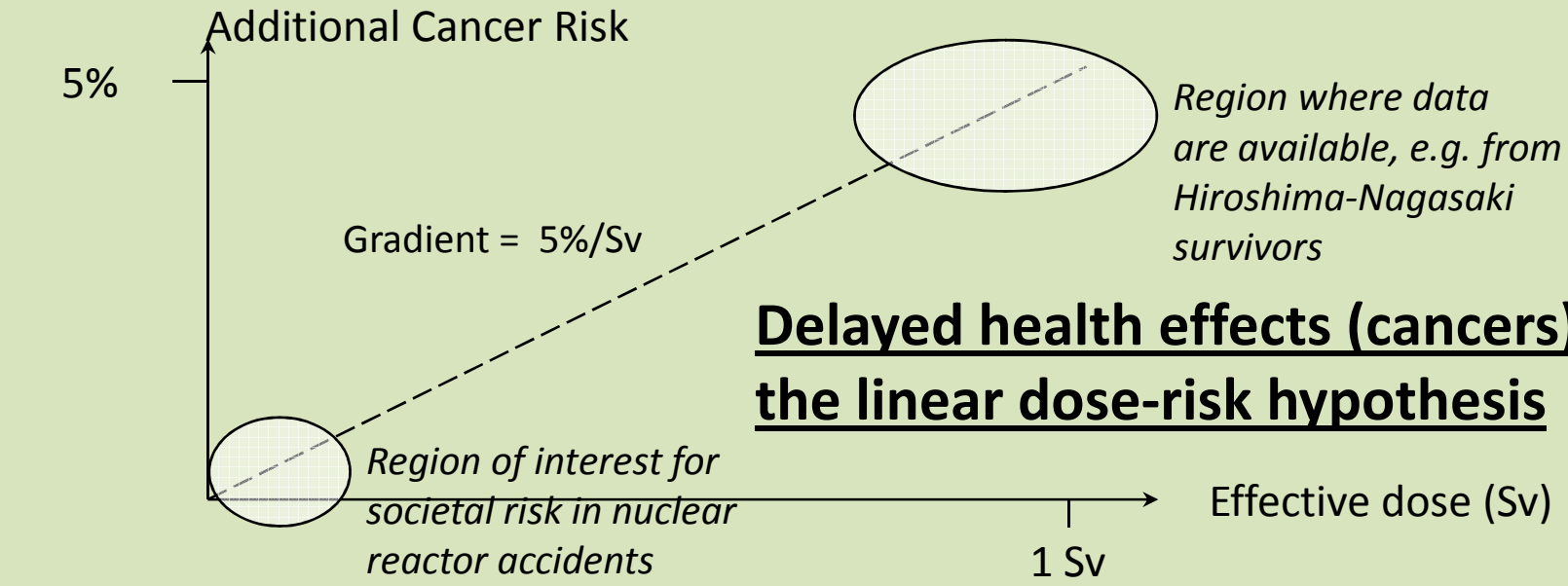
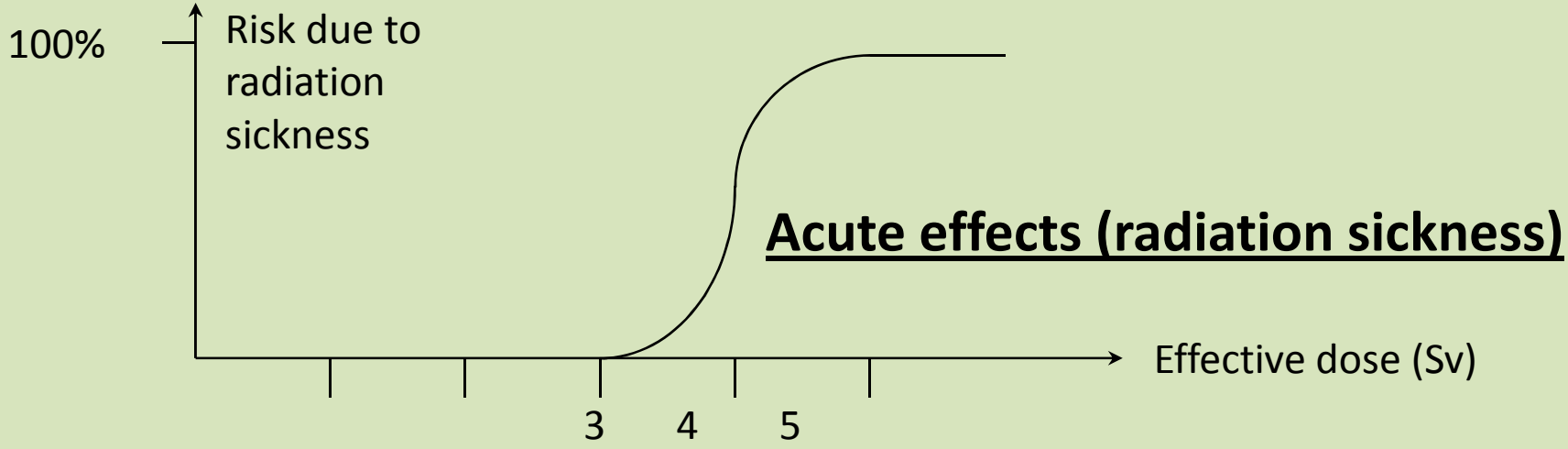
Radiation doses and radiological hazards

- *Other issue - Doserate effects - uncertain*
- *Normal cancer risk ~ 30%*



Delayed health effects (cancers) – the linear dose-risk hypothesis



Acute effects (radiation sickness)

Radiation doses and radiological hazards

- The Emergency Reference Level (ERL) = 300mSv effective dose

- Very small fractions of a reactor core's inventory would yield a major radiological hazard to the public if released off-site, e.g. typically a release of about one-millionth of the I-131 inventory in a reactor would equate to the Emergency Reference Level (ERL) for someone at the site boundary.

Isotopes	Characteristics
Iodine - 131	Volatile. Beta/gamma thyroid-seeker. Short half life (8d). Effects can be mitigated by swallowing iodate tablets.
Caesium - 137	Volatile. Permeates whole body (mimics sodium).
Actinides (e.g. Plutonium, Curium, Americium isotopes)	May be air-borne by fine particles of U_3O_8 in accidents. Alpha lung and bone seeker. Very long half lives.

Radiation doses and radiological hazards

4 different terms used:

DOSE is measured in Grays (Gy).
1 Gy = 1 Joule of radiation energy absorbed per kg of organ tissue

DOSE-EQUIVALENT is measured in Sieverts (Sv).
1 Sv = 1 Gy x *Relative Biological Effectiveness (RBE)*
where RBE = 1 for γ and β
20 for α and neutrons, which are more intensely ionising.

EFFECTIVE DOSE (Sv) is used to equate single organ dose-equivalents to a whole-body dose-equivalent. Various coefficients are used for different body organs.
Effective dose is an analogue for individual risk.
The risk of early death from 1 Sv (Effective) is judged by ICRP to be 5%.

COLLECTIVE EFFECTIVE DOSE (man-Sv) is used to measure integrated population effective doses and hence societal risks.

Nuclear event/incident classification - the INES scale

- The International Nuclear Event Scale (INES) is used to grade the severity of nuclear accidents.

- Events, incidents or accidents are graded 0 to 7 - analogous to the Richter scale for earthquakes - roughly logarithmic.

- INES 0 - 3 are operational events or incidents without major consequences.

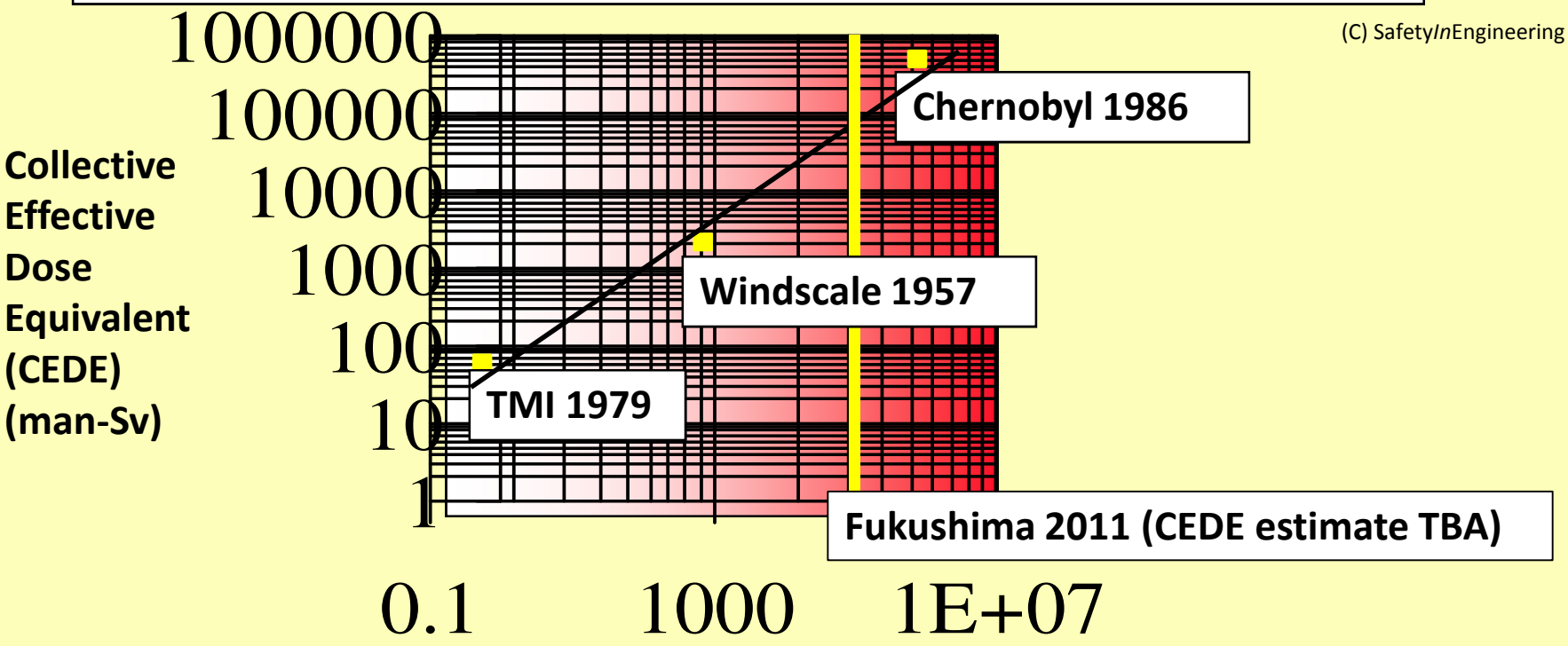
- The Three Mile Island accident (1979 - PWR loss of coolant) would have been INES 5.

- The Windscale fire (1957 - fire in air-cooled plutonium production reactor) would have been INES 5.

- The Chernobyl accident (1986 - reactivity excursion and steam explosion) would have been INES 7.

- Fukushima (2011 – earthquake/tsunami destroyed post-trip cooling) was rated INES 7

Consequences of reactor accidents – Fukushima update



Notes:

1. The above graph uses I -131 as a surrogate measure of radiological release. Other isotopes (notably Cs and Pu) will also have been significant. I-131 is used for simplicity as a common single measure of the magnitude of radioactive release.
2. CEDE estimates are taken from the relevant recognised 'definitive' reports (Kemeny, NRPB, IAEA).
3. Using the ICRP risk coefficient of 5E-02/man-Sv leads to deduced cancer mortality estimates from the accidents as follows:
   - TMI c.1
   - Windscale c.100
   - Chernobyl c.10000
4. Airborne releases after the Fukushima accidents were estimated to be 1.5E+5 TBq I-131 by the Japanese Government in their June 2011 report. CEDE estimates are not yet available. Fukushima also led to significant water-borne releases.
5. If the empirical correlation for the first three major accidents (the straight line on the graph) holds true for Fukushima also, then the deduced long-term cancer mortalities for Fukushima are likely to be of the order of 1000.