The reference monetary value of the man-sievert
Outcomes of an ISOE survey

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The concept

\[ \text{radiation protection option} \Rightarrow \text{averted dose (man.Sv)} \Rightarrow \text{cost (€)} \Rightarrow \text{cost of the averted dose (€/man.Sv)} \]

\[ \text{reference monetary value of the man-sievert “} \alpha \text{”} \]

\[ \alpha : \text{“the amount you agree to spend } \textit{a priori} \text{ to avoid a unit of collective dose”} \]

⇒ To assess the ‘reasonableness’ of a radiation protection decision, give priority and objectivity to the decision

Who use the concept? For what purposes? Values?
The 2017 ISOE survey

With the data from Asian + North America ISOE Technical Centres:

⇒ 18 regulatory bodies
⇒ 21 utilities and NPP (~ 220 reactors)
# Answers from regulatory bodies

<table>
<thead>
<tr>
<th>Countries</th>
<th>α values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belarus, Belgium, Canada, China, Finland, France, Germany, Japan, Lithuania, The Netherland, Slovenia, Spain, Sweden, Switzerland, Ukraine</td>
<td>To be based on a value of 3 millions €\textsubscript{2017} (general value; associated with the prevention of a cancer)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Several α values are recommended and appeared in regulatory documents</td>
</tr>
<tr>
<td></td>
<td>⇒ 7 values are proposed, depending on the level of exposure and the exposure situation</td>
</tr>
<tr>
<td></td>
<td>⇒ From 30 to 600 €\textsubscript{2016}/man.mSv</td>
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</tbody>
</table>

- Czech Republic
- Slovakia
Answers from utilities & NPP
Analysis – single $\alpha$ value

- From 446 to 5,000 €/man.mSv — Median = 1,200 €/man.mSv

⇒ Different *economics context* between the countries

⇒ *Updates ± recent*

but these cannot be the only explanations!

⇒ Essentially: *different approaches for setting $\alpha$*

  • ‘human capital’ method (Cernavoda NPP)
  • Value of Statistical Life + annual costs of a worker (Cook NPP)
  • $\alpha$ set by considering the values of other utilities (Vattenfall)

⇒ *Local radiation protection situation can also be taken into account*

  • Ex. $\alpha$ linked with the INPO ranking (Exelon (hybrid system))
Answers from utilities & NPP Analysis – set of αvalues

⇒ α increases with the level of exposure
Allow to spend more as the level of exposure increase

• Level of exposure are expressed very differently
• Dependence of $\alpha_{min}$, ... , $\alpha_{max}$ with the calculation model:

Ex. EDF: $\alpha(d) = \alpha_{ref} \cdot (d/d_0)^a$ ; $d_0=1$ mSv, $a=0.5$

Some tendencies since the previous ISOE surveys:

• The concept have been maintained or introduced (TEPCO, Japon)
• Increase of some values (USA, Sweden)
• New methods to set $\alpha$: Statistical Value of Human Life, feedback from other utilities

<table>
<thead>
<tr>
<th>TEPCO</th>
<th>5 bands of individual exposure; 1-50 mSv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leibstadt NPP</td>
<td>2 bands of individual exposure; 1-20 mSv</td>
</tr>
<tr>
<td>Krsko NPP</td>
<td>2 bands of collective exposure; 50 H.mSv</td>
</tr>
<tr>
<td>EDF</td>
<td>3 bands of individual exposure; 1-20 mSv</td>
</tr>
</tbody>
</table>
Used 1-10 times/year/organisation
Several examples of uses described
- Major modification, large scale project, chemical decontamination of system/circuit, power reduction
- Give priority to modifications on a long-term perspective

Only for ‘important’ decisions with radiation protection + economic + management etc. impacts
Radiation Protection Department first involved to elaborate the cost-benefit analysis; the decision is then taken at higher level

“A tool that allow more objectivity and transparency in the decision
— A tool among many [many] other decision factors”
Setting and using the reference value of the man-sievert

A synthesis

At the Gustavinum museum, Uppsala, Sweden
Introducing the reference value of the man-sievert: A synthesis

- Introduced in 1973, disseminated and still in use
- Comparing the collected values is not easy
  - different economic conditions, approaches (single vs. set), RP conditions, calculation etc.
- Used by Radiation Protection Department to give objectivity to the decision in a complex decisional context
- An help for the decision, not a decision cutting-value
- Trends:
  - A sustainable use of $\alpha$ over the years; regular updates + introduction
  - Appearance of more overall methods for setting $\alpha$
- In-line with trends in other sectors:
  - *Value in Health* Journal, «Everything has a cost» (SFSE congress, France, 2017)
Setting and using the reference value of the man-sievert

A synthesis

Thank you —
Annexe – Methods for setting alpha value

(1) Human capital

Estimation of the output that is lost to society on the premature death (based on the GNP/inhabitants and/or cost of workers)

- This is purely economic, and contain no allowance for other costs (e.g. cost to be spend due to the cancer) and subjective value (e.g. pain, suffering etc.)

- Ex. GNP/inhabitant = 34,300 € (France); ICRP risk coefficient 4.2.10^{-5} Sv^{-1}; number of years lost due to cancer: 16 years (cf. ICRP Publication 103):

  \[ 34,300 \times 4.2 \times 10^{-5} \times 16 = 23 \ €/H.mSv \]

- This is a minimum; can be increased with aversion: \( \alpha(d) = \alpha_0 \times (d/d_0)^a \), \( a = 1.5 \)

(2) Implied or revealed preference

Retrospective analysis of decisions of protection that have been implemented and how much has been spent to reduce the risk

- To deduce an implicit socially-acceptable value of life
- But very specific to the risk, population, decision-maker, ground of decision etc.
Annexe – Methods for setting alpha value

- (3) Willingness to pay
- How much are individuals willing to pay to avoid a given amount of risk?
- Determined by tailored survey + (meta-)analysis
- An overall approach, considered the most theoretically sounded, to evaluate the “Statistical Value of Human Life”
- Ex. 3.14 M€ in France (Quinet, 2013); 3M€ on average in OECD countries (OECD, 2012); 9M$ for US NRC etc.