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

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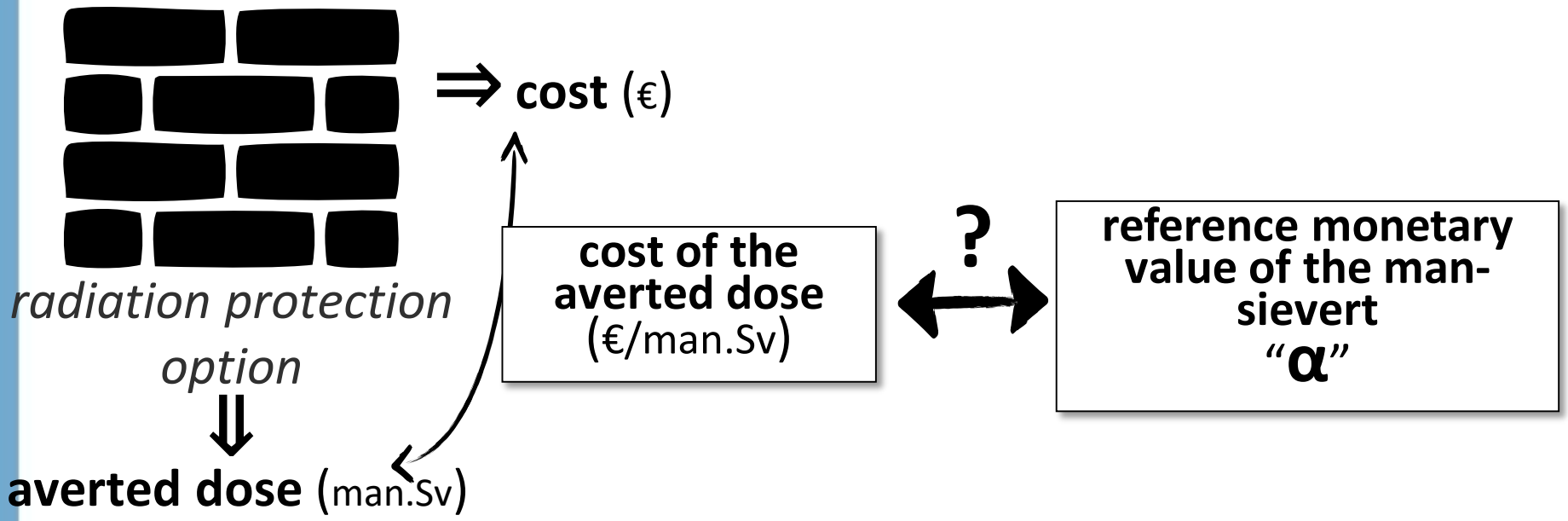
The concept



α : "the amount you agree to spend *a priori* 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

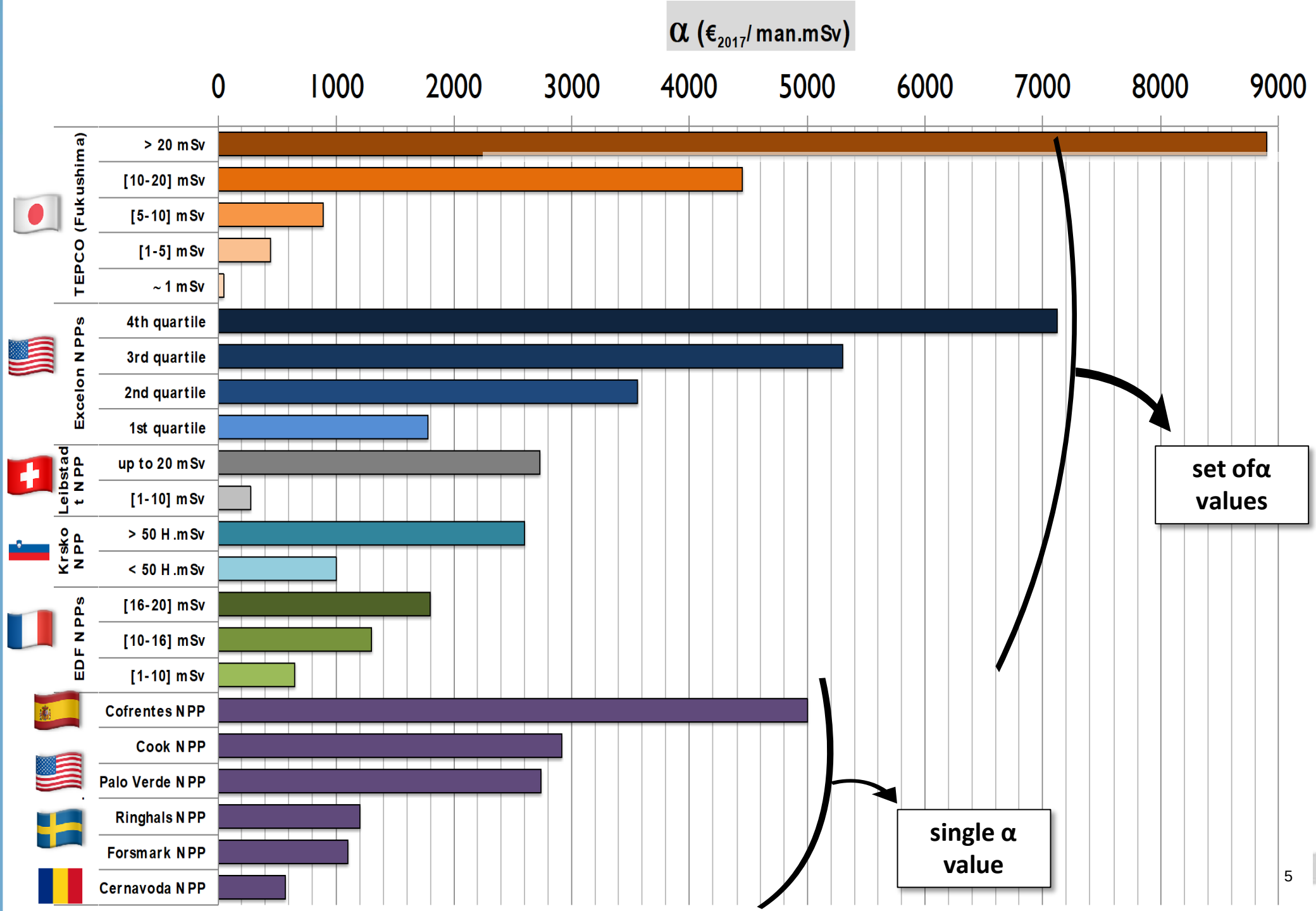
With the data from Asian + North America ISOE Technical Centres:

⇒ **18 regulatory bodies**

⇒ **21 utilities and NPP** (~ 220 reactors)

Answers from regulatory bodies

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


α (€2017/ man.mSv)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
TEPCO (Fukushima)
> 20 mSv
[10-20] mSv
[5-10] mSv
[1-5] mSv
~ 1 mSv
Excelon NPPs
4th quartile
3rd quartile
2nd quartile
1st quartile
Leibstadt NPP
up to 20 mSv
[1-10] mSv
Krsko NPP
> 50 H.mSv
< 50 H.mSv
EDF NPPs
[16-20] mSv
[10-16] mSv
[1-10] mSv
Cofrentes NPP
Cook NPP
Palo Verde NPP
Ringhals NPP
Forsmark NPP
Cernavoda NPP
set ofα values
single α value

Answers from utilities & NPP Analysis – single αvalue

- 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 settingα*

- *'human capital' method (Cernavoda NPP)*
- *Value of Statistical Life + annual costs of a worker (Cook NPP)*
- *α set by considering the values of other utilities (Vattenfall)*

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

- Ex. *α 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* α_{min} *, … ,* α_{max} *with the* ***calculation model*** *:*

  Ex. EDF: $\alpha(d)=\alpha_{ref} . (d/d_0)^a$; d_0=1 mSv, a=0,5

TEPCO
5 bands of individual exposure; 1-50 mSv

Leibstadt NPP
2 bands of individual exposure; 1-20 mSv

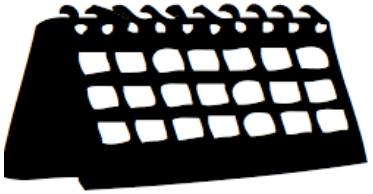
Krsko NPP
2 bands of collective exposure; 50 H.mSv

EDF
3 bands of individual exposure; 1-20 mSv

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 setα : Statistical Value of Human Life, feedback from other utilities*

Answers from utilities & NPP
Uses and users



⇒ 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

Setting and using 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 α over the years; regular updates + introduction
  - Appearance of more overall methods for setting α
- In-line with trends in other sectors:
  - *Judgment-value* (Thomas, P. J., Stupples, D. W., and Alghaffar, M. A., Pro. Saf. Env. Prot. 2006)
  - *Value in Health* Journal, « *Everything has a cost* » (SFSE congress, France, 2017)

Setting and using the reference value of the man-sievert
A synthesis

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):

$$34{,}300 \times 4.2.10^{-5} \times 16 = 23\ €/H.mSv$$

  - This is a minimum; can be increased with *aversion*: $\alpha(d) = \alpha_0 \times (d/d0)^a$, 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.