Review of cost-benefit analysis (CBA) methodology for decision-making related to safety modifications

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Summary

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1. Context of Cost Benefit Assessment (CBA)

Current concern of legislators and industry to argue in terms of costs and quantified impacts for environmental and industrial choices

Often employed in United States, Scandinavian countries, United Kingdom, European project ExternE

In the nuclear field, initiative of Safety Authorities (Canada's or US) or utilities in Europe

2. Paper's purpose

Present the international situation of the cost-benefit analysis (CBA) performed by safety authorities and utilities for the decision making process on nuclear power plant safety modifications:

- Nuclear Regulatory Commission (NRC) and the US Research Institutes (EPRI, MIT)
- CANDU Owners Group (COG)
- Europe :
  - Health and Safety Executive (HSE) in UK
  - Utilities and Safety Authority in Spain
  - Paks NPP in Hungary
  - ExternE

3. Définition of CBA in the Nuclear field

- **The modification cost is weighted against the expected benefit in plant safety**

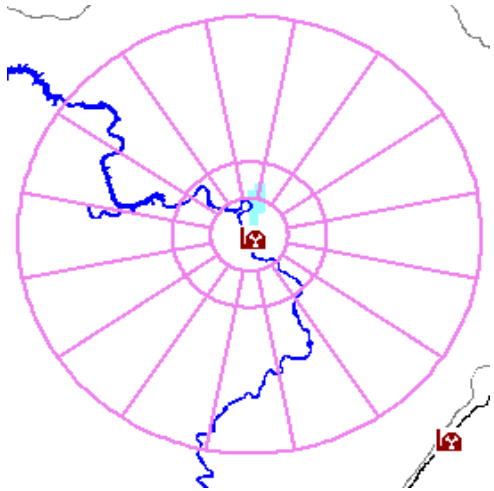
- **Modification's safety benefit :** avoided impacts cost in case of accident (PSA model)

- **Avoided impacts cost** can be internal or external for the electricity producer. An external cost (or externality) is a cost imposed on the community not supported by producers.

4. Quantification of avoided Impacts (I)

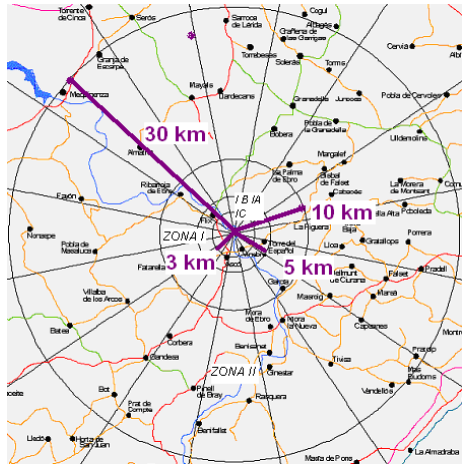
Type of avoided impact :

- Collective risk : all methods
- Individual risk (COG, HSE, EPRI and ExternE)
- Onsite impact : all methods except ExternE
- Offsite impact : quantifications proposed by NRC, UNESA and ExternE
- ExternE the most complete : indirect non-monetary impacts (suffering) and indirect macroeconomic impacts



4. Quantification of avoided Impacts (II)

- **Quantitative estimation of an impact is based:**
  - on the reduction in Core Damage or/and Releases Frequency (PSA)
  - on the reduction in accident consequences cost (COSYMA, MACCS, RODOS)
    - Release categories definition (vary among the countries)
    - Site and geographic area specificities (80 km radius NRC, 200 km (COG) or 3000 km for ExternE)
  - on past accident experience (Tchernobyl)



- **Quantifications are often based on NRC's recommendations and studies**

4. Quantification of avoided Impacts (III)

- **Limits in quantitative estimation of an impact**
  - cost of the land and loss of crops and animals for a limited period of time (MACCS: 30-year horizon)
  - Health (fatal cancers) damage's horizon time is about 50 years (MACCS)
  - Simplification concerning the impact on next generation population
  - knowledge of physical phenomena is limited today
  - experts are not always in agreement (example : Chernobyl)
- **Methods use assumptions to simplify and thus obtain conservative results**
- **Results are usually used in relative terms with a disproportion factor to have a precautionary margin as in EDF's approach**

5. Decision Support (I)

Ratio B/C, B-C

Cost-benefit :

To evaluate the possibility of taking or not taking action

The most exhaustive quantification (take into account all the benefits) but difficult to quantify indirect impacts

Cost-effectiveness :

Doesn't need exhaustive assessment because is used in relative terms in two ways:

- Choosing the most suitable alternative for a given problem (COG, NRC, UNESA, EDF)
- To search the maximum effectiveness of an alternative within a constraint cost (compliance with a budget, ranking alternatives for ten-year inspections)

5. Decision Support (II)

Uncertainty modelled :

- indirectly through precautionary margins (disproportion factor) and generally conservative assumptions (prudent and often practiced but not adapted in terms of risk aversion)

  1 (NRC's, EPRI's, COG's), 20 ExternE, HSE varies

- directly, by modelling the risk aversion to correct the assessments value which does not include a disproportion factor or a smaller one (less practiced)
- the intermediary between the two options outlined above. This means to incorporate a risk premium in the discount rate (criticized for being arbitrary)

5. Decision Support (III)

Uncertainty treatment :

Purpose: to check the robustness of CBA results

Method used is importance analysis followed by sensitive/uncertain data analysis :

- Importance analysis establishes the contribution of each attribute to benefits or to costs
- Sensitivity/uncertainty analysis is recommended only for data that may have a significant effect on the value of the attribute considered
- Sensitive studies on assumptions and models are recommended in COG and NRC approaches

6. EDF methodology

A cost-effectiveness approach

Six safety assessment criteria :

- Risk of core damage without loss of containment (CD)
- Risk of release with early loss of containment (a few hours) (LER)
- Risk of early release due to containment leakage (SLR)
- Risk of indirect (or filtered) release without early loss of containment
- Risk of late release due to basemat breakthrough
- Doses without core damage in h * mSv / yr

7. Conclusion (I)

International coherence :

- Consistency between impacts evaluated and for values proposed for their estimation :
  - Most important impacts considered are health, offsite and onsite damage
  - CBA approach considers only direct consequences in their benefit
- precautionary margin for disproportion factor and conservative assumption => not to seek an economical optimum

7. Conclusion (II)

Applications confirm the interest of this decision-making tool

- Third ten-yearly outage inspections 900 Mwe French reactors: more than 97% of the safety benefit achieved by a 31% of total cost modifications

Decision-making can by no means be devolved automatically to cost-benefit :

- "The regulatory authorities did not accept that analysis C/B is the only way to decide on the acceptability of a nuclear power unit safety“

  (Nuclear Energy Agency NEA, 1995)

This tool should be a vector for change in the dialogue with the Safety Authority