Reflection on Risk Analysis

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Today's lecture is about

Part 1: The evolution of safety in nuclear reactor design

- Active, passive and inherently safe reactors
- Different methods of safety improvements

Part 2: How to assess the acceptability of risk

- Informed consent
- Risk benefit analysis (and distribution)

Part 1:
The evolution of safety in nuclear reactor design

Evolution of safety in reactor design

Safety was even important in world's first reactor built by Fermi in 1942

Evolution of safety in reactor design

Safety has been particularly important after nuclear accidents

- Three Mile Island in 1979: discussions in the US
- Chernobyl in 1986: discussions reached Europe too
- Still unclear how Fukushima affects reactor design philosophy

Evolution of safety in reactor design

Three safety regimes: (IAEA 1991)

- Active
  - reliance on external mechanisms such as power in accidents
- Passive
  - human intervention unnecessary - natural laws e.g. gravity
- Inherent
  - elimination or exclusion of inherent hazards through design

Probabilistic Risk Assessments I

Probabilistic Risk Assessments proposed by Rasmussen in 1975

- Mapping all the events that could go wrong
- And assigning probabilities

Probabilistic Risk Assessments II

Rasmussen calculated the melt-down risk of a reactor: $5x10^{-5}$

- Or once in every 20,000 reactor years
- Based on 500 reactors, one accident every 40 years

Probabilistic Risk Assessments III

TMI accident was roughly in line with Rasmussen's estimated risk

What was decisive for designing safer reactors was the anticipated growth

- To possibly 5,000 reactors, thus 10 times more reactors years
- Hence, ten times higher risk of accident: one every 4 years

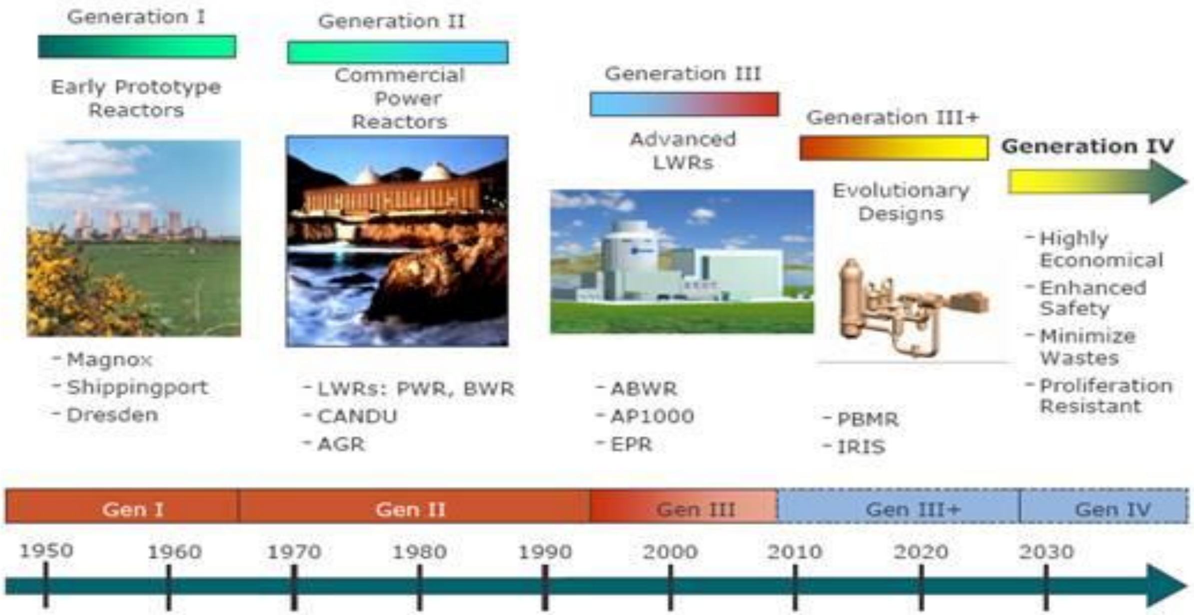
Two approaches to safer reactors

Incremental changes in the safety

- Taking current designs as the departing point
- And adding safety features (or removing reasons of accidents)

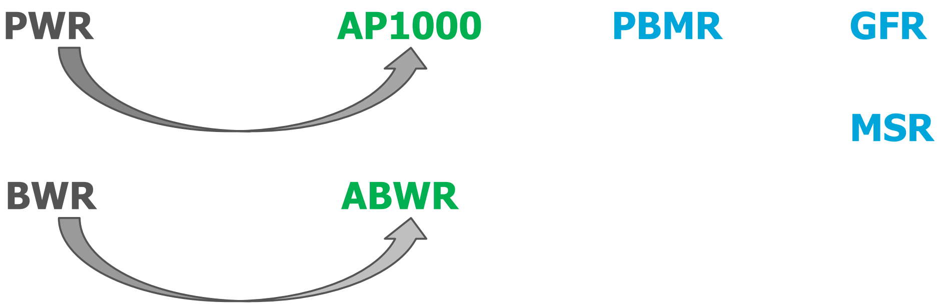
Taking a **radical** approach to design

- Starting from scratch with safety as leading design criterion



Green: incremental improvements

Blue: radical design change



PRA and policy

PRA, as proposed by Rasmussen, is mainly for identifying and eliminating weaknesses in reactor design

PRA and policy

Nowadays, they serve different purposes, mainly in policy

- IAEA: new reactors must have CDF< 1 in 100,000 RY
- Legislators use a variety of such frequencies

In addition to safety, we design reactors for other criteria too

- Security
- Sustainability and resource durability
- Resource durability

Part 2:
How to assess the acceptability of risk

The gap between acceptance and acceptability

Acceptance refers to public acceptance

Acceptability includes broader ethical issues

- Multidimensionality of risk
- Voluntariness of risk
- Risk benefit distribution

Reliability of estimated risk

Both car accidents and nuclear plant melt-down risks in terms of probability times impact

How are these risks estimated?

- The former using statistical data, the latter using many assumptions, models, simulations and expert opinion

Reliability of estimated risk

Bayesian belief in risk estimation

- Experts with authoritative opinions are asked to assess the risk
- Quantifying risk makes it more tangible, but it adds a subjective element to risk assessment

Multidimensionality of risk

Risk has many dimensions (fatalities, injuries etc.)

Risk assessments often take fatality as the criterion

- To avoid discussions on what constitutes an injury
- But, these reduce multidimensional risk to one dimension

Multidimensionality of risk

How should we take different risk dimensions into account?

- How to weight sever injuries and fatalities?
- How many severe injuries equal one death?

Informed consent

Many believe that 'consent' is primary ethical criterion

Informed consent is the proposed principle

- The affected parties should be fully informed about the consequences and they should consent to this risk
- This principle is rooted in the moral principle of **autonomy**

Informed consent

Informed consent is common in medical ethics

- The (individual) patient should consent to risk, or veto it

Ho to apply it to technology and collective risk

- No *veto* rights could be given to each individual

Distribution of risks and benefits

We will discuss the issue of distribution for CBA

- Hence, a risky treatment should always have benefits

Distribution also determines acceptability

- Aggregative methods do not automatically deal with this issue

Distribution of risks and benefits

To what extent is the imposition of risk on (a group of) individuals legitimate when the benefits are unevenly distributed

- In medical ethics this principle is straightforward
- Less straightforward for technological projects and when collective risks involved

How to deal with uncertainties

Uncertainty and ignorance in technical innovation and application of (new) technology

The Precautionary Principle as a guiding principle

New approaches to the introduction of technology

- New technology as a social experiment that should continuously be evaluated

In sum,

Part 1: *Safety has always been important in designing nuclear* reactors

- Incremental and radical safety improvements

Other criteria such as security, sustainability are important too

Part 2: *We need to asses societal and ethical issues of risk acceptability*

- Risk distribution
- Informed consent
- The precautionary Principle

Thank you for your attention!