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# The cost of nuclear accidents



# Estimating the costs of nuclear accidents

# Benefits of safety

- Costs of accidents are the benefits of safety
- The benefits of safety should be well understood
  - Unfortunately, this is not always the case
- If the Japanese had estimated the cost of a major accident in Fukushima, they might have avoided the enormous toll this accident is taking on the Japanese nuclear industry

# Full safety benefits

## ↔ Comprehensive cost

- No element of cost should be left out.
- Else, cost estimates are underestimated
- If accident costs are underestimated, the value of prevention will also be underestimated.
- Prevention expenses will then be lower than what would be optimal and excessive risk will be retained.

# Nuclear crisis is vast

- The “consequences”» approach previously followed implied:
  1. Calculating health effects and food bans (quantities), in general within an operational crisis management framework
  2. Multiplying these quantities by unit prices, which provides costs
    - Thus: zero Becquerel = zero cost
  
- In contrast, the economic approach advocates:
  1. Establishing a complete list of the effects of a nuclear crisis
  2. Then estimating corresponding costs
    - Some costs items correspond to zero Becquerel situations...

# Complete Costs

## RADIOLOGICAL COSTS

### Off-site radiological costs

Emergency countermeasures  
Health (radiological)  
Food related losses

Psychological costs

### Contaminated Territories

Exclusion zones  
Other contaminated territories

+

*Classical  
consequence  
approach*

## ECONOMIC COSTS

### Onsite costs

Decontamination and decommissioning  
Electricity production losses  
Other onsite costs

### Image

Food related products  
Tourism  
Other exports

### Costs related to electricity production

# Indirect costs?

- The above categories – radiological and economic costs – do not match a hypothetical distinction between direct and “indirect” costs
- In economic terms, there is a definition: indirect costs are all those borne by agents which are not in the “front line”, which do not feel the blow directly but rather through the actions taken by “front line” victims
- In legal terms, for compensation purposes, a “direct” causal link is required. Insurance companies master the art of defining damages as indirect, but this has no economic basis.
- In contrast, we see no definition which would qualify Image costs as indirect – or, for that matter, stochastic health effects as direct...
- We suggest this terminology is unfounded, unhelpful and should be abandoned

# Scenarios

- In order to cover the full spectrum of accidents on a 900 MWe French PWR...
- ... two broad accident families were distinguished
  - so-called “severe” accidents
  - and so-called “major” accidents, such as Fukushima or Chernobyl
- Ideally, all types of accidents should be covered
  - even if believed to have very low ex-ante probability
  - and including domino effects



# The severe nuclear accident in France

# The severe accident

- Core melt on a French 900 MWe PWR followed by radioactive releases, more or less controlled and therefore *not massive*
- Source terms can be more or less severe in this accident family weather conditions can be more or less favorable
- Figures are estimated from the point of view of France they would differ from the point of view of the affected region and again from the point of view of the European Union

# 2012 Cost of a representative severe nuclear accident in France

	b€	%
On-site costs	6	5%
Offsite radiological costs	9	8%
Contaminated territories	11	10%
Costs related to power production	44	37%
Image costs	47	40%
Total (rounded)	120	100%

# A national but manageable catastrophe

	b€
On-site costs	6
Offsite radiological costs	9
Contaminated territories	11
Costs related to power production	44
Image costs	47
Total (rounded)	120

- A national disaster (€120b)
  - Around 6% of annual GDP; 3-6 years of economic growth
  - Recent major industrial accidents only cost around € 2b...
  - Image costs and power costs account for 77% of the total and are practically not related to the particular region affected by the accident

# A national but manageable catastrophe

	b€
On-site costs	6
Offsite radiological costs	9
Contaminated territories	11
Costs related to power production	44
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Total (rounded)	120

- A manageable crisis
  - Purely radiological costs would account for less than 20%
  - Radiological refugees could be in the order of 3 500 (from 0 to 10000... only...)
  - High-level crisis managers would face media chaos and high economic stakes rather than a full-blown radiological catastrophe

# A largely economic disaster

	b€
On-site costs	6
Offsite radiological costs	9
Contaminated territories	11
Costs related to power production	44
Image costs	47
Total (rounded)	120

- Economic costs completely dominate
  - How could crisis management be efficient if this were not acknowledged?
- Limiting cost to offsite radiological costs?
  - would severely underestimate costs to the nation
  - vastly underestimate the value of prevention
  - other things equal, lead to retain greatly excessive risk

# The major accident in France

# The major accident

- Core melt on a French 900 MWe PWR followed by *massive* releases
- Again source terms can be more or less severe and weather conditions can be more or less favorable
- Again figures are estimated from the point of view of France, would differ from the point of view of the affected region, and from the point of view of the European Union

# 2012 Cost of a representative major nuclear accident in France

	b€	%
On-site costs	8	2%
Offsite radiological costs	53	13%
Contaminated territories	110	26%
Costs related to power production	90	21%
Image costs	166	39%
Total (rounded)	430	100%

# A major radiological catastrophe

## 1 - radiological costs

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
Costs related to power production	90
Image costs	166
Total (rounded)	430

- Radiological consequences could cost more than € 160b i.e. more than the *total* cost of a severe accident.
- Costs of contaminated territories exceed 5% of annual GDP.

# A major radiological catastrophe

## 2 - victims

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
Costs related to power production	90
Image costs	166
Total (rounded)	430

- Radiological refugees, could typically number 100 000
- Psychological impacts would be significant
- Quantities of lost agricultural produce to be disposed of would be considerable
- Management of contaminated territories (apart from exclusion zones) would remain an on-going challenge for many years
- Neighboring countries would often also suffer from contamination

# A major radiological catastrophe

## 3 - implications

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
Costs related to power production	90
Image costs	166
Total (rounded)	430

- Widespread suffering for affected populations
- Corresponding costs could be termed “human” costs and could elicit among decision makers a high level of willingness to pay for prevention
- In total, “human” costs would represent about 40% of total costs but might weigh more heavily in decisions

# High “economic” costs

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
Costs related to power production	90
Image costs	166
Total (rounded)	430

- Image costs and Power costs are more diffuse and shared among the entire population;
- Image costs could reach the staggering figure of more than € 160b – as much as radiological costs
- Economic costs are again dominant in purely monetary terms

# Huge total losses

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
Costs related to power production	90
Image costs	166
Total (rounded)	430

- In total, a typical major accident could cost more than € 400b
  - more than 20% of annual French GDP,
  - more than 10 years' economic growth
- The country would face a radiological crisis roughly comparable to Fukushima and, in addition, would face extremely heavy losses. In all probability, this would lead to profound political and social transitions.

# Huge total losses

	b€
On-site costs	8
Offsite radiological costs	53
Contaminated territories	110
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Total (rounded)	430

- Such a blow would durably stun the country, History would remember the catastrophe for decades, Western Europe would globally be affected.
- Such extreme cases carry huge stakes for the nation
- Their lower probability may not balance their catastrophic potential.

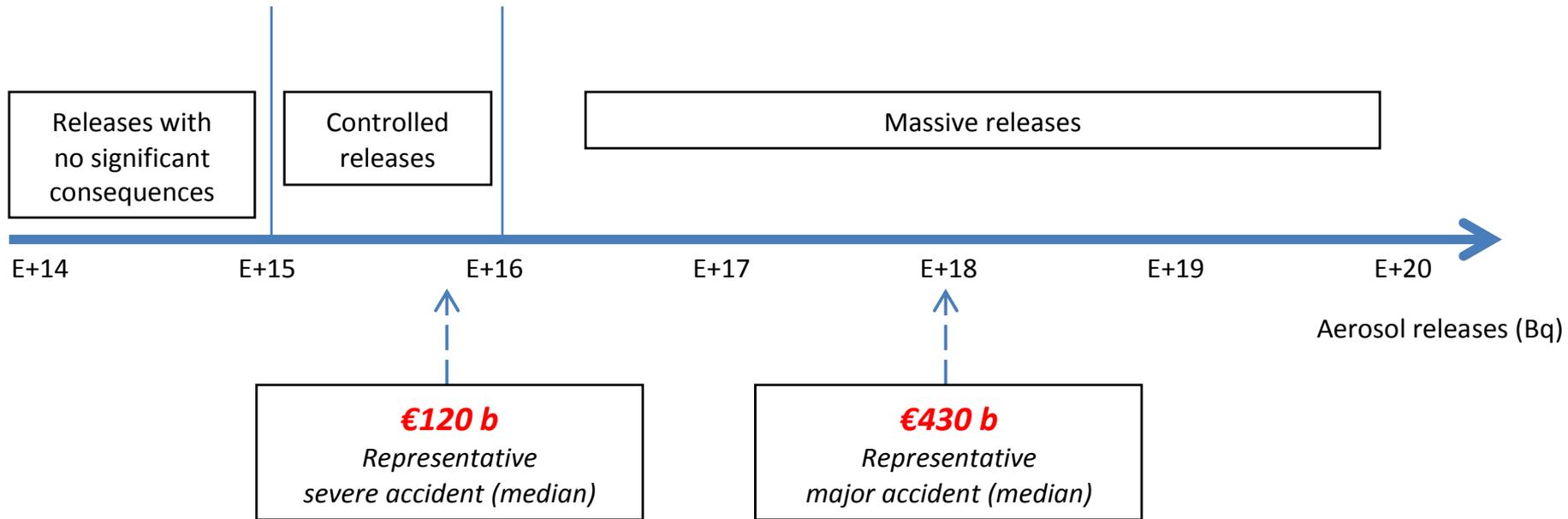
# Concluding remarks

- Accident cost estimation is an integrative activity
  - combines the analysis of 14 cost lines (grouped into 5 broad cost lines)
  - provides a stunning global picture of the accident, a vivid insight into the benefits of safety
  - even when based on global representative figures
- Further studies are needed to understand
  - site-based variations and specifics
  - the full distributions wrt climatic conditions

# Reminder

- Poor knowledge of accident costs means poor knowledge of safety benefits
- Poor quantification of accident costs translates into underestimation of safety benefits
- which in turn leads to excessive risk being retained
- which is, eventually, detrimental to nuclear industry (cf. Fukushima)

# Glimpse of 2012 landscape



*Figures attempt to be median with respect to climatic conditions and all other parameters*

Thank you for your attention