IAEA activities related to the estimations of nuclear accident costs

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Approaches to estimation of the costs of nuclear accidents

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International Atomic Energy Agency

Overview

- Planning and Economic Studies Section, IAEA
- IAEA activities following Fukushima
- IAEA activities related to evaluating the costs of nuclear accidents
- Direct & indirect costs
- Other costs and impacts
- The cost of accidents vs. the cost of safety

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Planning and Economic Studies Section (PESS)

- Energy modeling & capacity building
  - Develop energy planning tools
  - Build capacity for tools
  - Provide training and technical support
- Economic, financial, and environmental assessments
- Analysis of options for energy strategies
- Techno-economic analysis
  - e.g. comparison of long-term carbon sequestration vs. radioactive storage
- Research on development-energy linkages
- Contributions to international efforts on sustainable energy development and climate change

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IAEA involvement in accident cost estimates

- PESS has not worked directly on the issue of estimating costs of nuclear accidents
- PESS is conducting related research on the economic implications of climate change and extreme weather events on nuclear facilities
- The IAEA was very involved in the aftermath of Fukushima, though from a safety, response, and regulatory perspective rather than a cost/economics perspective.

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IAEA after TEPCO's Fukushima accident

- IAEA convened a Ministerial Conference on Nuclear Safety in June 2011 to undertake an assessment of the accident and identify needed actions to improve:
  - Safety
  - Emergency preparedness and response
  - Global nuclear safety framework
- IAEA established an Action Plan on Nuclear Safety
  - National safety assessments ("stress tests") were conducted
  - IAEA convened 4 related International Experts' Meetings
  - IAEA upgraded its emergency response plan
  - IAEA revising safety standards

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IAEA Action Plan on Nuclear Safety – Nuclear Liability

- All MS with nuclear should adhere to one or more updated international nuclear liability instruments; adopt consistent national laws
- All MS should establish treaty relations with as many States as practical to achieve universal participation in a global nuclear liability regime
- MS without nuclear should consider adhering to a global liability regime given the benefits entitle to potential victims of accidents
- All MS with nuclear should ensure that there are adequate funds available to compensate all victims of a nuclear incident
  - Security amounts significantly higher than minimum amounts under existing instruments
  - Undertake regular reviews of the adequacy of compensation amounts

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Impacts of climate change and extreme weather events on nuclear facilities and other energy infrastructure

- Began as a workshop in Trieste in 2010
- Current research will be published in journal *Climatic Change*
- Just launched a coordinated research project involving Argentina, China, Cuba, Egypt, Ghana, Pakistan, Slovenia, and Sudan
  - Partner institutions from each of these Member States will evaluate the impacts of climate change and extreme weather on nuclear and other energy infrastructure and develop risk-based adaptation plans
  - Partners will estimate the cost of damage to nuclear facilities caused by extreme weather events as part of their evaluations

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Extreme weather events

	High Winds & Lightning	Extreme Temperature	Precipitation	Droughts	Floods/Sea Level Rise	Forest & Wildfire
PP Generation	Can create false signals to instrumentation	Heat reduces the thermal efficiency of plants; heat can limit water discharge when temperatures are too high and can reduce the effectiveness of cooling *See also PP Safety Systems*		Low water levels can force plants to reduce output because water for cooling is too scarce	Some coastal plants are increasingly vulnerable to storm surges with climate change, which can disrupt generation	Can disrupt plant access by personnel and delivery vehicles
PP Safety Systems	Can damage diesel generators and make inoperable; can damage buildings with wind-generated missiles	Low: Ice can clog water cooling system; snow and ice can inhibit plant access; freezing pipes can lead to internal flooding High: rapid algae and other biological growth can block cooling systems	Excessive rain or snow can collapse unreinforced structures	Low water can force a shutdown and potential create a safety issue	Some coastal plants are increasingly vulnerable to storm surges with climate change, which can disrupt safety systems	Can disrupt emergency plant access
PP Grid Connection	Can knock out transmission lines and take grid offline	Low: Ice can knock out tramsmission lines and take grid offline High: Heat can affect the transmission capacity of grid; increases probability of blackout			Some coastal plants are increasingly vulnerable to storm surges with climate change, which can disrupt grid interconnections	Forest and wild fires can knock out transmission lines and cut off access to grid
PP SF/RW storage	Can damage buildings with wind-generated missiles				Some coastal plants are increasingly vulnerable to storm surges with climate change, which can threaten SF/RW storage	
Fuel cycle upstream					Flooding can disrupt uranium mining operations	
Fuel cycle downstream						

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Potential extreme events at nuclear plants whose economic impact has been modeled in literature

○ = not modelled ● = modelled	Nuclear
Higher mean temperatures*	●
Changes in rainfall patterns	●
Lightning	○
High winds	○
Sand storms and dust	○
Extreme cold	○
Extreme heat*	●
Floods	○
Drought	●
Sea-level rise	○

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Direct costs

- Emergency service costs
- Evacuation and short term relocation of population
- Individual and population exposure to radiation
- Contamination of farm land, crops, animals and their products
- External contamination of dwellings
- Internal contamination of dwellings
- Permanent relocation of population
- External contamination of commercial/industrial units
- Internal contamination of commercial/industrial units
- Relocation of businesses

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Source: Higgins et al, "COCO-2: A Model to Assess the Economic Impact of an Accident," Health Protection Agency, HPA-RPD-046

Indirect costs

- Disruption of business
- Disruption of public services
- Disruption of networks (communication, transport, electricity, etc.)
- Disruption of households
- Loss of tourism

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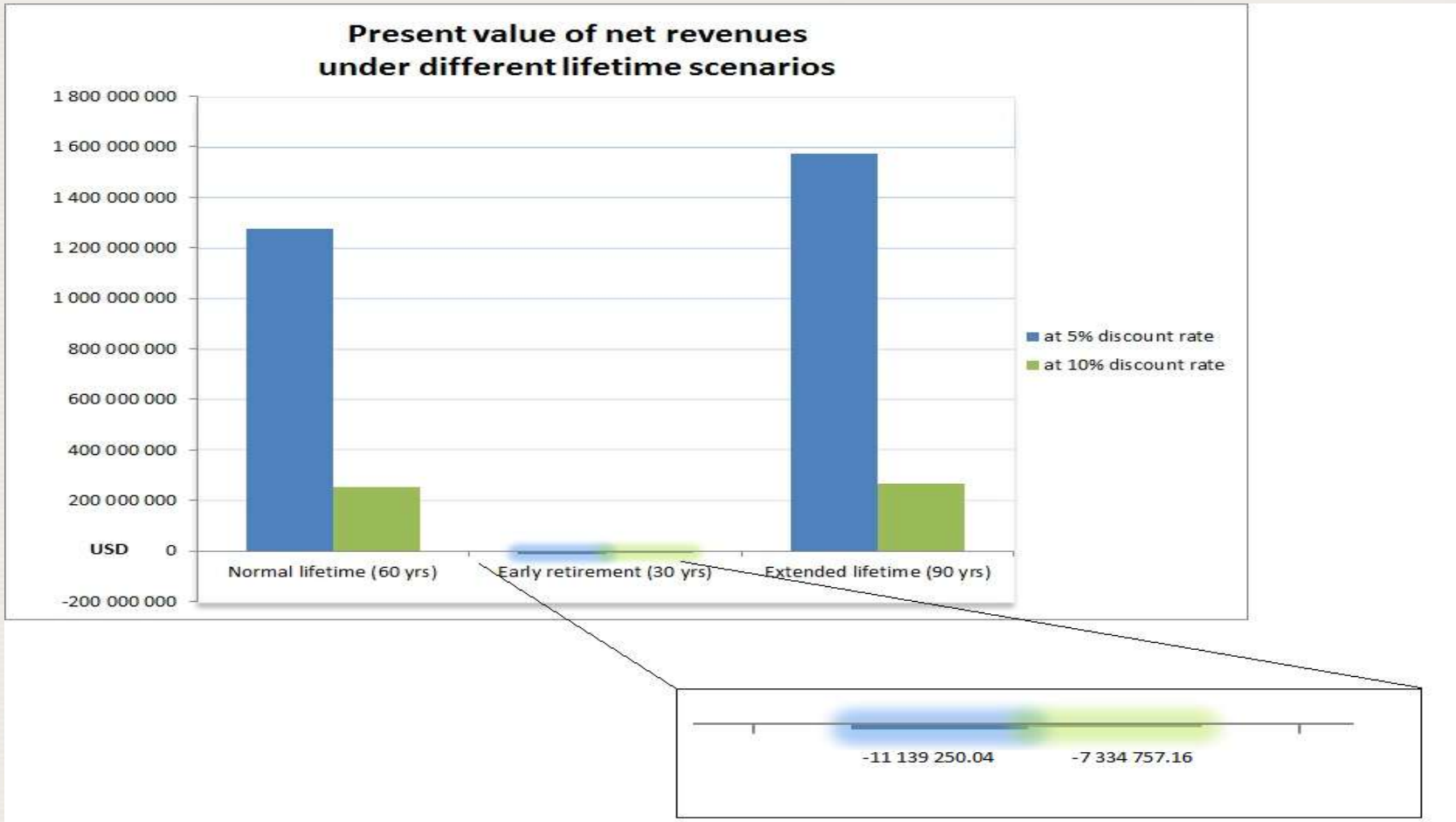
Source: Higgins et al, “COCO-2: A Model to Assess the Economic Impact of an Accident,” Health Protection Agency, HPA-RPD-046

Other costs and impacts

- Loss of generation output from nuclear plant
- Cost of replacement generation
- Price instability
- Environmental implications of replacement generation

Loss of generation

- PV of net revenues: unexpected loss of nuclear plant after 30 years



Cost of replacement power

- Institute of Energy Economics, Japan (IEEJ) estimates that the average cost of generation rose 8.6% in Japan in 2012 as a result of replacement power costs
- Japan imported 11.2% more LNG in 2012 than in 2011, and LNG prices have increased 55% from 2010 to 2012

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Macroeconomic implications

- Price instability can lead to:
  - Price of fuel increases ->
  - Price of electricity increases ->
  - Production costs increase ->
  - Increase in cost of consumer goods ->
  - Inflationary impact ->
  - Central bank increases interest rate to keep inflation in check ->
  - GDP decreases ->

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Environmental implications of replacement generation

- Replacement generation will most likely be fossil-based, which will increase CO2 emissions and air pollutants
  - Risk of climate change increases
  - Increased health effects from air pollution
- Not only replacement generation for affected nuclear plants, but a single disaster like Fukushima can shift unaffected countries away from nuclear toward fossil-based plants

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The cost of accidents vs the cost of safety

- Fukushima clean-up costs between $250 billion (NewsonJapan.com, “Fukushima Cleanup Could Cost up to $250 Billion” *NewsOnJapan.com.* 6 Nov. 2012) and $500 billion (Gundersen, Arnie & Caldicott, Helen. “The Ongoing Damage and Danger at Fukushima.” *Fairewinds Energy Education.* Web. 6 Nov. 2012)
- $316 million per reactor unit in Japan based on lessons learned from Fukushima (Nucleonics Week, March 21, 2013, Volume 54, Number 12)
- US nuclear safety upgrades: $23.5 billion (http://www.nuclearenergyinsider.com/us-plant-safety-enhancements/index.php)
- France: extra safety measures will cost about $13 billion (http://www.nuclearenergyinsider.com/us-plant-safety-enhancements/index.php)

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Thank you!

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