FILTERS AND FILTERING STRATEGIES

Industry Detailed Comments on SECY-12-0157

February 4, 2013

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INDUSTRY PROPOSAL FOR OPTION 4

Overall Industry Approach

- Stepped back from filter/no filter question
  - What is the best way to manage a severe core damage event in a BWR Mark I/II?
- Integrated view of plant scenarios, severe accident response, and uncertainties
  - EPRI report highlighted both the good and the bad
- Integrated view essential
  - 50.54(hh)(2) vs. FLEX
- BWROG table top pilot provided a real application

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Functional Capabilities

Functional Capability	Purpose	Performance Attributes
Reliable water injection via sprays	• Cool core debris in drywell to preserve containment integrity • Remove heat from drywell atmosphere to protect containment integrity • Capture radionuclides in containment	1. Approximately 500 gpm of water injection via spray headers 2. Plug and play connection external to reactor building for portable pump/fire truck connection capable of supporting required flow 3. Pumps (N+1) and water source sufficient to support spray capability 4. Programmatic controls to ensure reliability 5. Implementing procedures, guidance, and training
Reliable containment venting	• Maintain containment pressure in acceptable range to reduce pressure challenges to containment integrity	1. Severe accident capable wetwell and drywell vent a. Capable of remote operation b. Capable of local manual operation 2. Pressure control capability to maintain pressure within desired control band 3. Programmatic controls to ensure reliability 4. Implementing procedures, guidance, and training

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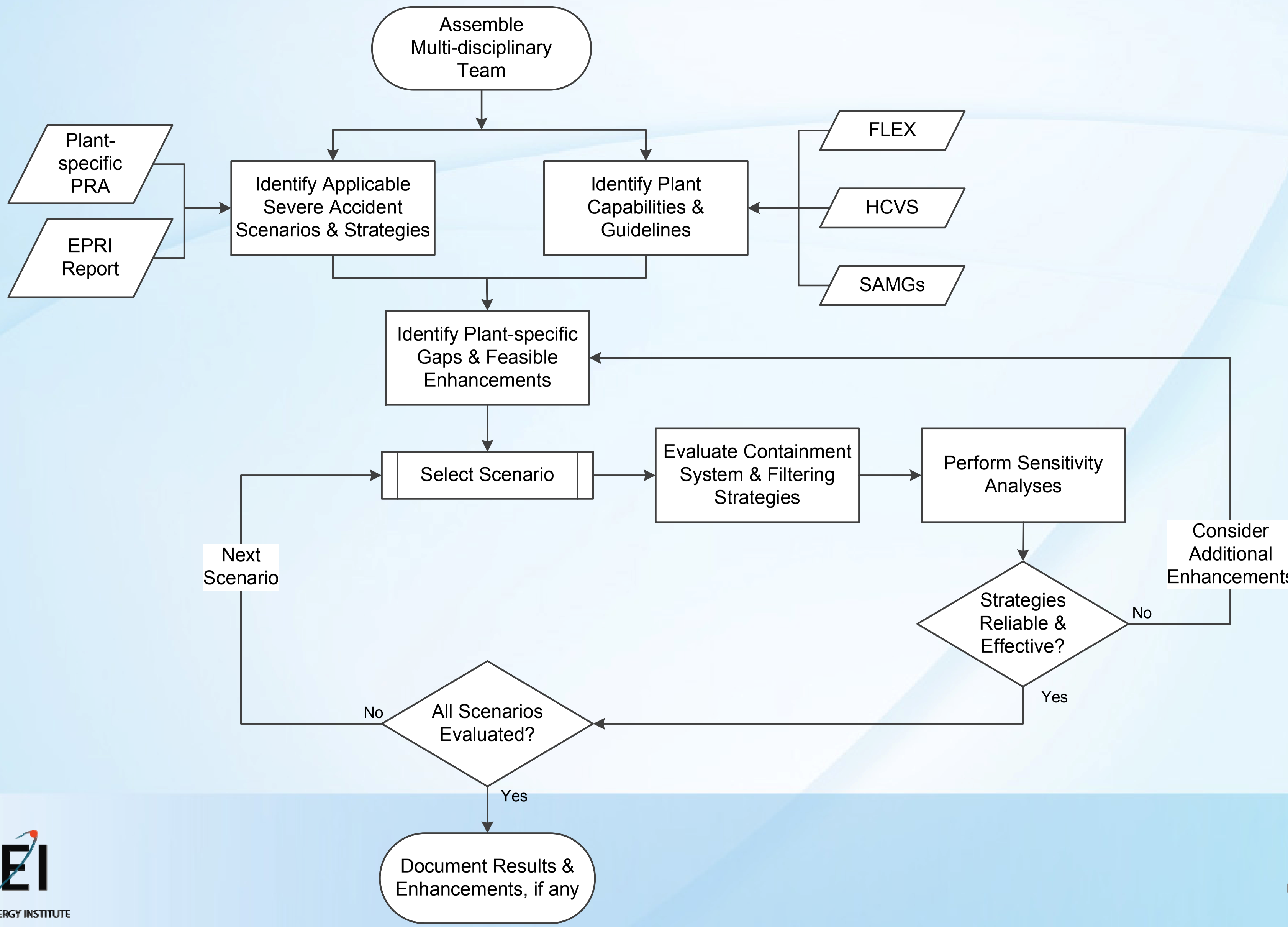
Proposed Path Forward

- Modify EA 12-050 & ISG to require severe accident capable RHVs on both the wetwell and drywell
- Expedited rulemaking on performance-based approach
- Establish performance-based guidance for industry implementation
  - Process like used at BWROG pilot to confirm capability and procedures
- Option to install filter available if plant-specific implementation not reliable and effective

Site Implementation Process



Timeline for Option 3 or 4 Rulemaking

Date	Action	Time to Completion
T+O	Commission directs staff to initiate rulemaking	0
T+6 months	Staff and industry develop regulatory basis and draft guidance in support of proposed rule. Proposed rule text and statements of consideration developed in parallel.	6 months (using FLEX guidance as the benchmark)
T+7.5 months	Proposed Rule and draft implementation guidance issued for comment	45 day comment period
T+13.5 months	Staff prepares final rule and guidance with consideration of comments	6 months from conclusion of comment period
T+15.5 months	OMB Review	60 days
T+16 months	Final Rule and guidance published	2 weeks after OMB approval
T+22 months	Licensees develop and submit site-specific implementation plans for NRC review and approval	6 months (using FLEX plans as the benchmark)
T+28 months	NRC Reviews site-specific plans and issues approvals	6 months (based on projected FLEX review schedule)
T+ 64-76 months	Full site-specific implementation complete	2 refueling cycles after plan approval (36 to 48 months)

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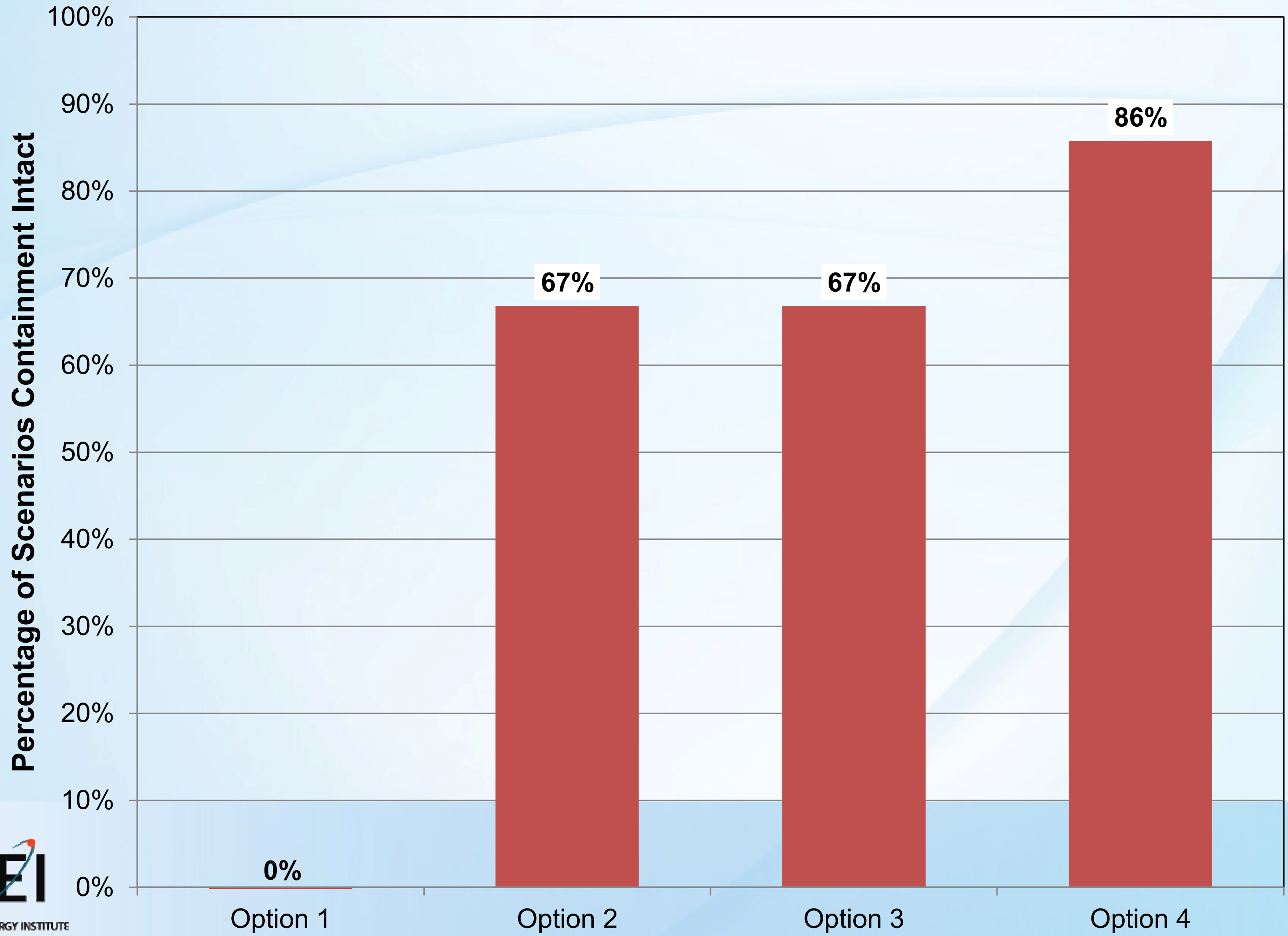
EVALUATION OF OPTION 4

Overview

- Used framework and data from SECY 12-0157 to evaluate industry proposal (Option 4)
- Extended quantitative evaluation to consider:
  - Defense-in-Depth
  - Realistic credit for B5b (50.54hh(2))
  - Quantitative uncertainty analysis
- Reevaluation of qualitative factors

Preservation of Containment Integrity



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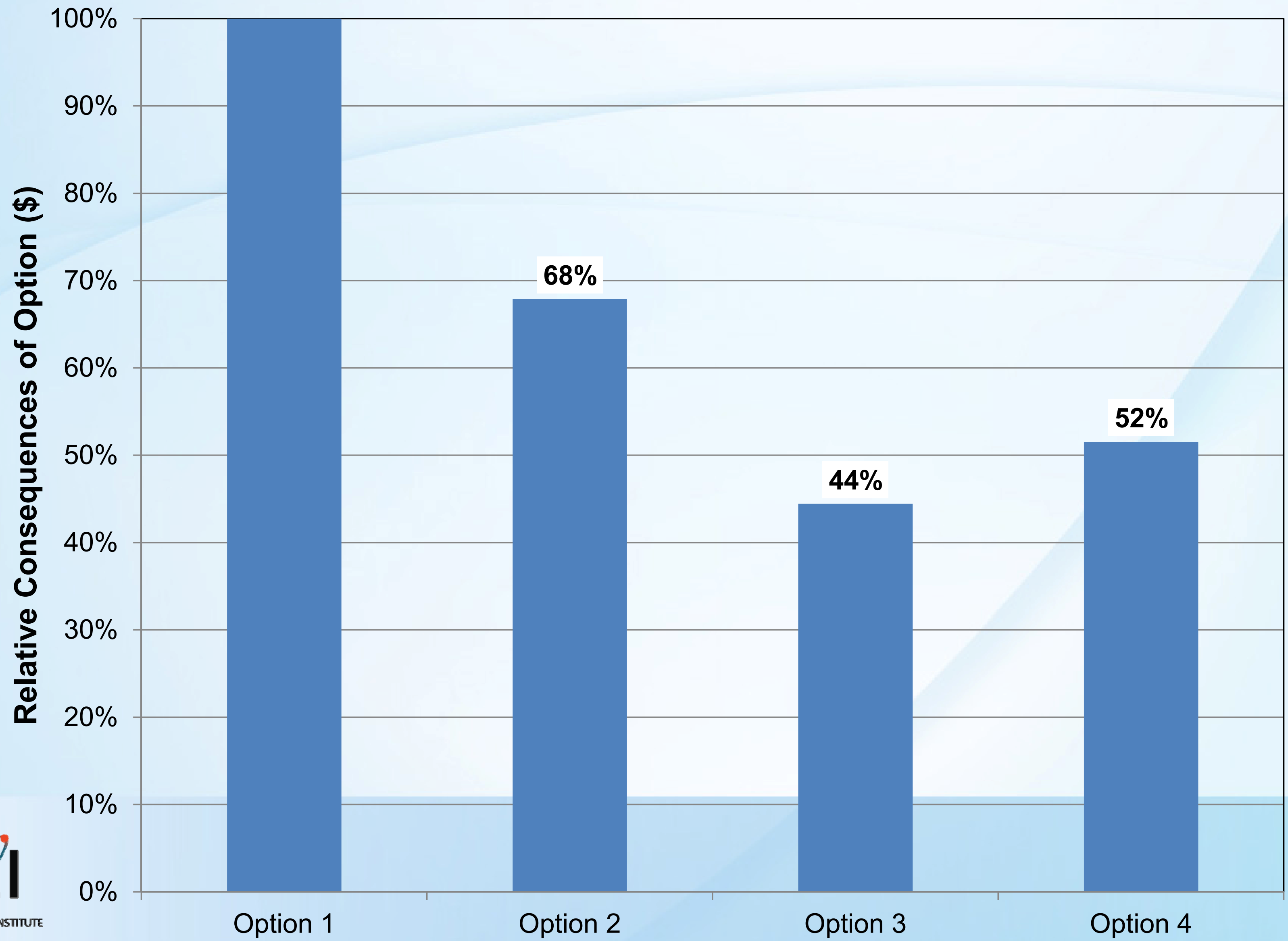
Comparison of Computed Residual Consequences



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Credit for B5b Equipment

- SECY credits B5b equipment to provide inject water into drywell for debris cooling
- B5b equipment:
  - Protected from large fire & explosion, not external hazards
  - Limited capability (e.g., 12 hours of water & fuel)
  - Connections not necessarily permanently installed or rugged against external hazards

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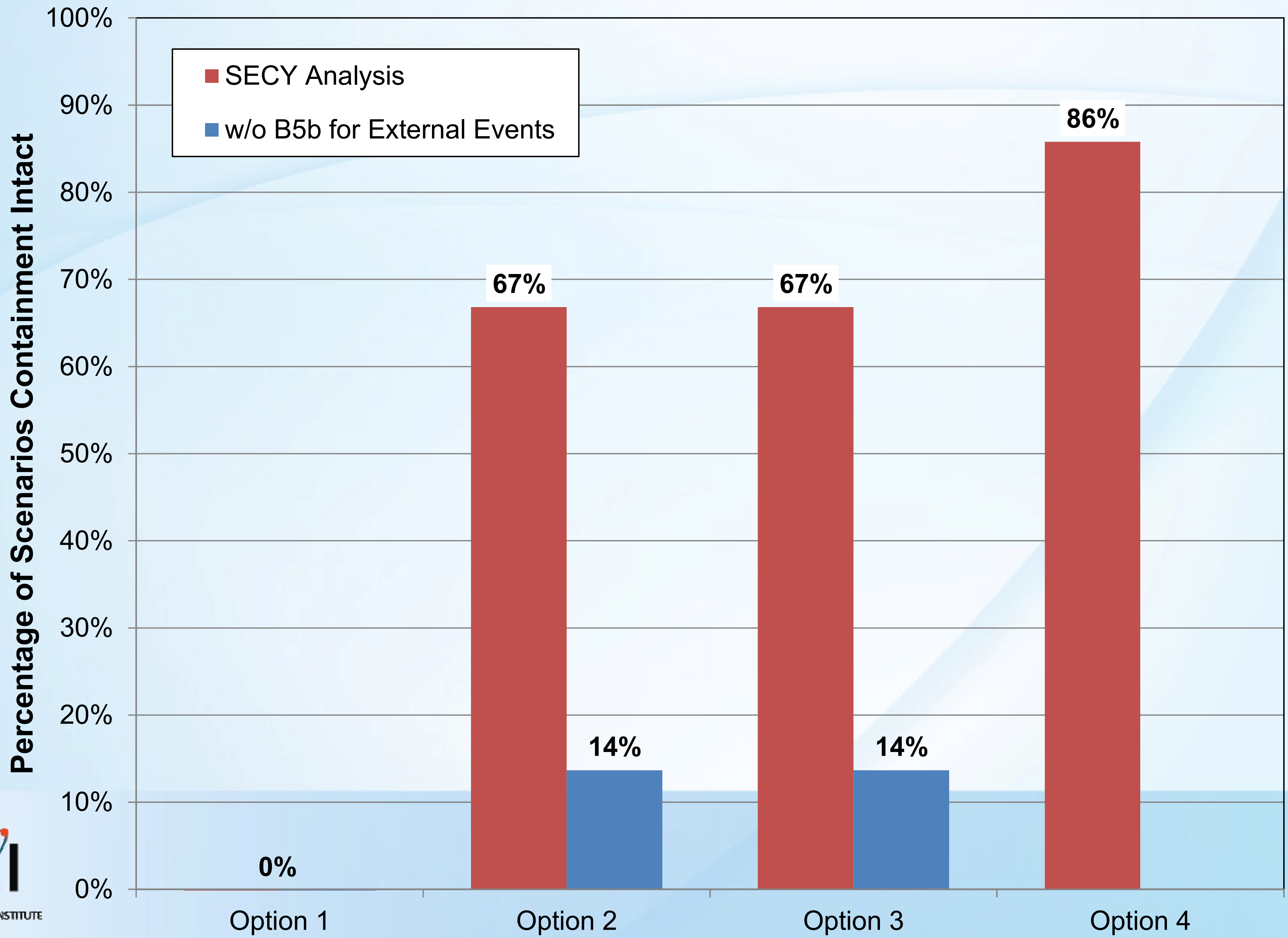
Containment Integrity Comparison



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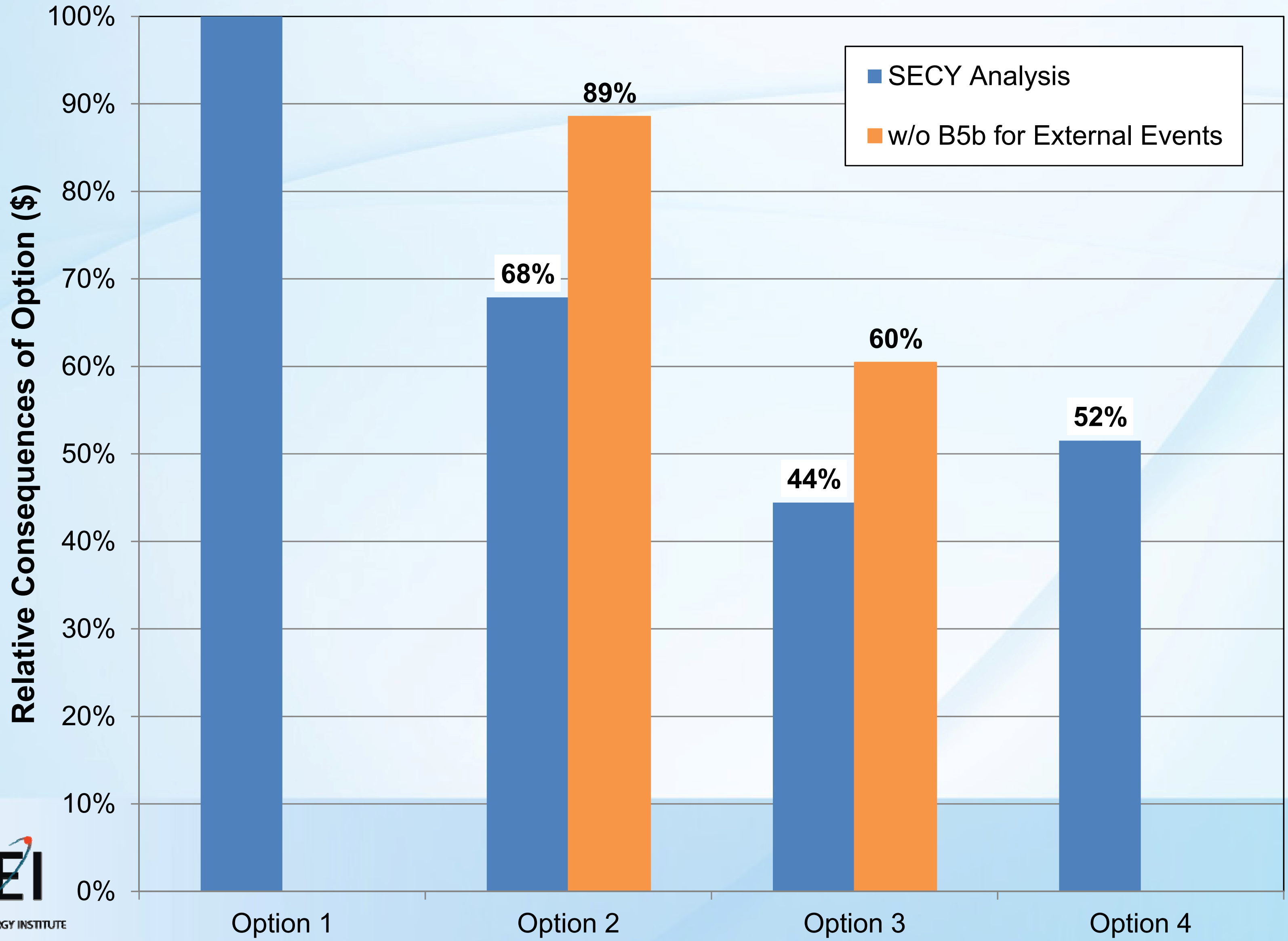
Comparison of Consequences



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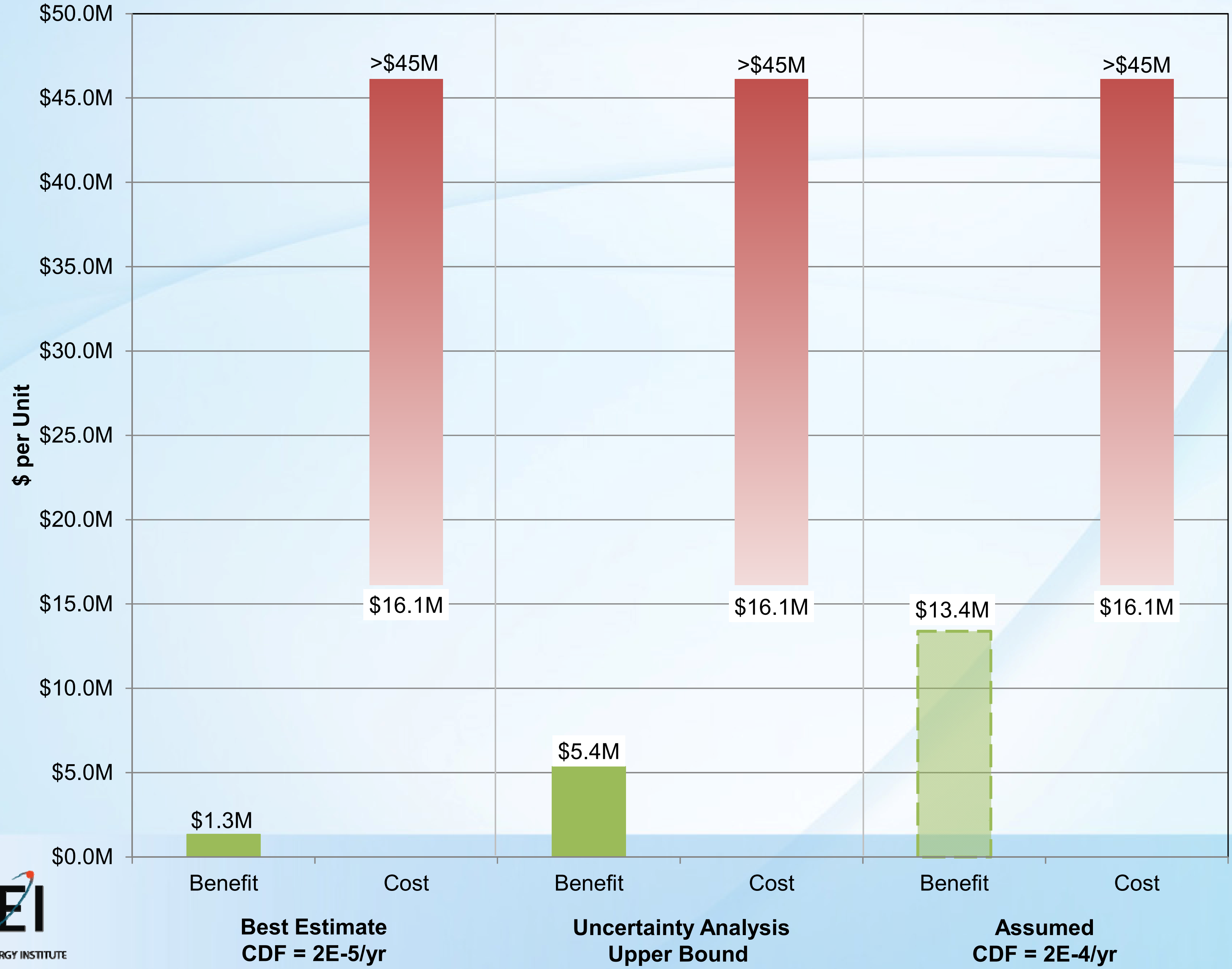
Quantitative Uncertainties

- Enclosure 1 of SECY 12-057 states that the upper bound results are a factor of 10 above the base (mean) results
- Enclosure 1 uses the sensitivity using a factor of 10 as the basis for filters being potentially cost-beneficial

Cost & Benefit Comparison



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Summary of Qualitative Factors

	Option 1	Option 2	Option 3	Option 4
Defense in Depth		☑	☑☑☑ (third crossed out with red X)	☑☑☑
Uncertainties		☑	☑☑☑	☑☑☑
Severe Accident Management		☑	☑☑	☑☑☑
Hydrogen Control		☑☑	☑☑	☑☑
External Events		☑	☑☑	☑☑
Multi-unit Events		☑	☑☑	☑☑
Independence of Barriers		☑	☑☑☑ (third crossed out with red X)	☑☑☑
~~Emergency Planning~~		~~☑~~	~~☑☑☑~~	~~☑☑~~
Consistency between Technologies	☑☑☑			☑
Severe Accident Policy	☑☑			☑
International Practices		☑	☑☑☑	☑☑

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TECHNICAL AND POLICY ISSUES

Technical and Policy Issues

- Re-definition and Extension of Containment
- “Upper Bound” Results
- Qualitative Issues
- Regulatory Analysis Guidelines
- Balanced assessment of Option 4
- Characterization of Engineered Filter Proposal as Passive
- Failure Modes & Unintended Consequences of Filters
- Consideration of Engineering Practicalities of Filters
- Prospective Analysis
- Stylized Scenarios
- Relationship to SOARCA
- Characterization of EPRI Analysis

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COMPARISON TO ACRS PERFORMANCE ATTRIBUTES

ACRS November 8, 2012 Letter

We recommend the implementation of Option 4, Performance-Based Approach, to reduce radioactive material releases as a needed defense-in-depth measure for BWR Mark I and Mark II containments."

ACRS Attributes for a Performance-based Approach

ACRS Attribute	How Addressed By Industry Proposal
Keep the loads on the containment well below design levels most of the time	Both pressure and temperature challenges addressed for a broad spectrum of accidents
Rely primarily on passive components and reduce the need for manual actions or transportation of heavy pieces of equipment	Active debris cooling is required. Reliable vent and spray provide greatest confidence in preserving containment integrity
Compatible with actions to flood the drywell and mitigate the potential for overfilling the wetwell	Provides reliable injection to drywell. SAMGs address required mitigation actions.
Rely on scrubbing by the suppression pool & keep the pool temperature well below saturation	Suppression pool effectiveness maximized by injection of subcooled water and pressure control
Preserve the integrity of the drywell head seal	Drywell pressure and temperature management
Address hydrogen control as well as radioactive releases	Management of drywell temperature and pressure and control of venting address hydrogen

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COMMENTS ON DRAFT ORDERS

Overview

- Major Issues
  - Not feasible to respond affirmatively within 20 days without significantly more clear requirements
  - Not possible to design severe accident vent systems like design basis features
  - Proposed timeline does not appear realistic
- Specific Technical Issues
  - Roughly half of performance criteria not adequately defined

Summary of Issues

Type of Issue	Applicable Criteria
Not sufficiently defined	1.1.1, 1.3
Essentially unbounded	1.1.3, 1.1.4, 1.2.5, 1.2.6, 1.2.12, 1.3.1, 2.1
Introduce potential design basis conflict	1.2.1, 1.2.2
Not feasible to design for all severe accident conditions	1.2.11
Not possible	1.3.2

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Benefit of Performance-based Approach

- Integrated strategy provides more straightforward design requirements
- Reliable and effective water injection and containment venting provides boundaries on scenarios and inputs

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BACKUP SLIDES

Industry Assessment of Option 4

CD	Hazard	Sequence Type	Vent	OSP Recovery	Portable Pump	Seq	Status	Frequency	%	MACCS2 Case
2.00E-05	internal 0.2	other 0.83	0.95		0.95	1	Vented	3.00E-06	15%	14
					0.05	2	LMT	1.58E-07	1%	3NF
			5.00E-02			3	OP + LMT	1.66E-07	1%	2NF
		SBO 0.12	0.95	0.62		4	Vented	2.83E-07	1%	14
				0.38	0.95	5	Vented	1.65E-07	1%	14
					0.05	6	LMT	8.66E-09	0%	3NF
			5.00E-02	0.62		7	OP	1.49E-08	0%	6NF
				0.38		8	OP + LMT	9.12E-09	0%	2NF
		bypass 0.05				9	OP + LMT	2.00E-07	1%	2NF
		fast 0.01	0.95		0.95	10	Vented	3.61E-08	0%	14
					0.05	11	LMT	1.90E-09	0%	3NF
			5.00E-02			12	OP + LMT	2.00E-09	0%	2NF
	external 0.8	other 0.95	0.95		0.95	13	Vented	1.37E-05	69%	14
					0.05	14	LMT	7.22E-07	4%	3NF
			5.00E-02			15	OP + LMT	7.60E-07	4%	2NF
		bypass 0.05				16	OP + LMT	8.00E-07	4%	2NF
								CCFP =	14%	

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Expanded Table 6 from Enclosure 5c. Parameter Values Used in the Risk Evaluation

Parameter	Value		Basis
CDF	2E-5/reactor-year		SPAR external hazard models
Fraction of total CDF due to external hazards	0.8		SPAR external hazard models; review of previous PRAs
Breakdown of sequence types for internal hazards	Other (not SBO, bypass or fast)	0.83	SPAR internal hazard models
	SBO	0.12	
	Bypass (ISLOCAs)	0.05	
	Fast (MLOCAs, LLOCAs, ATWS)	0.01	
Breakdown of sequence types for external hazards	Other (not bypass)	0.95	Review of previous PRAs; engineering judgment
	Bypass	0.05	
Probability that SA vent fails to open	Mod 0	1	
	Mods 1, 3, 5, 7—other or SBO	0.3	SPAR-H method (manual vent; longer available time)
	Mods 1, 3, 5, 7—fast	0.5	SPAR-H method (manual vent; shorter available time)
	Mods 2, 4, 6, 8	0.001	Engineering judgment (passive vent mechanical failure)
	Reliable Severe Accident Vent (Option 4)	0.05	SPAR-H method and equipment reliability
Conditional probability that offsite power is not recovered by the time of lower head failure given not recovered at the time of core damage (internal hazards)	0.38		Historical data (NUREG-6890)
Probability that portable pump for core spray or drywell spray fails	0.3		SPAR-H; consistent with SPAR B.5.b study done by Idaho National Laboratory
Probability that external injection to drywell sprays fails	0.05		SPAR-H and equipment reliability

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Basis for Consequence – Case 14

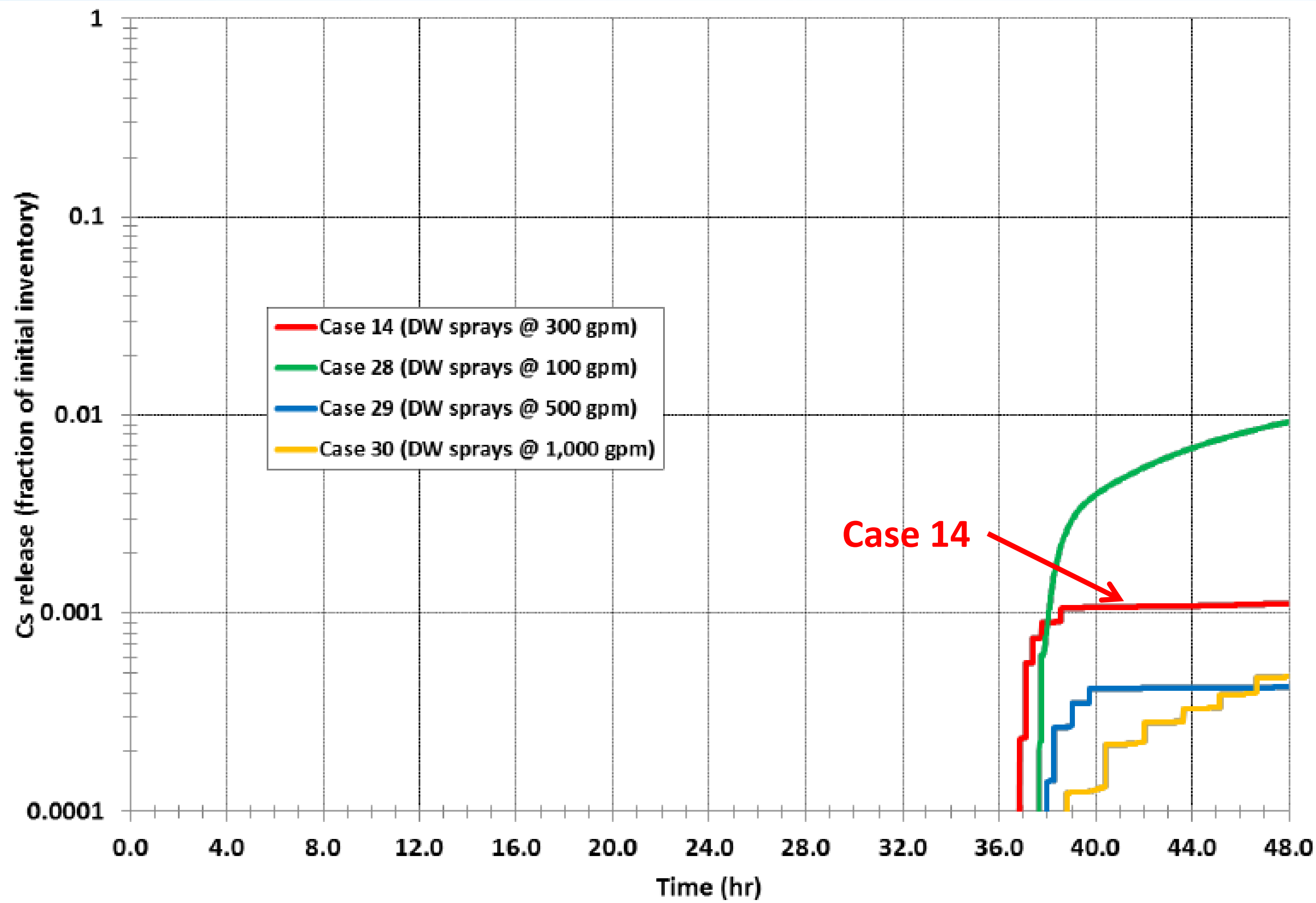

Figure 25. Effect of drywell spray flow rate on cesium release fraction

Ref.: Enc. 5a, SECY 12-0157

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Containment Failure Modes

Expanded Table 9 of Enc. 5c. Breakdown of Containment Failure Modes[1]

Mod	Vent Filtered	Vent Location	Vent Actuation	End State: Vent	End State: LMT	End State: OP	End State: LMT + OP	CCFP	
0	n/a	None	n/a	0 0%	0 0%	3E-7 1.5%	2E-5 98.5%	100%	Option 1
1	No	Wetwell	Manual	9E-6 46.8%	4E-6 19.6%	9E-8 0.4%	7E-6 33.1%	53.2%	
3	No	Drywell	Manual						
5	Yes	Wetwell	Manual						
7	Yes	Drywell	Manual						
2	No	Wetwell	Passive	1E-5 66.9%	6E-6 28.0%	3E-10 0.0%	1E-6 5.1%	33.1%	Options 2 & 3
4	No	Drywell	Passive						
6	Yes	Wetwell	Passive						
8	Yes	Drywell	Passive						
Opt. 4	No	Wetwell	Reliable Manual	1.7E-5 86.0%	9E-7 4.5%	1E-8 0.1%	2E-6 9.7%	14.0%	Option 4

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Computation of Benefit

Benefits of Severe Accident Capable and Filtered Vent System $ K Per Unit (Adapted from Table 1 of Enclosure 1)[1]			
	Severe Accident Capable Venting Systems	**Engineered Filtered Venting Systems**	**Option 4 – Performance-based Filtering**
Factor	**Best Estimate Frequency of $2x10^{-5}$ / ry**	**Best Estimate Frequency of $2x10^{-5}$ / ry**	**Best Estimate Frequency of $2x10^{-5}$ / ry**
Public Health	150	290	260
Occupational Health	11	19	11
Offsite Property	348	600	538
Onsite Property	268†	430†	240‡
TOTAL BENEFIT	777	1339	1038

† - These values could not be regenerated.

‡ - This value is computed based on Excel workbook, but appears to be biased low as compared to the SECY.

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B5b Sensitivity for Option 3

CD	Hazard	Sequence Type	Vent	OSP Recovery	Portable Pump	Seq	Status	Frequency	%	MACCS2 Case
					0.7	1	Vented	2.32E-06	12%	7F
		other	0.999		0.3	2	LMT	9.95E-07	5%	3F
		0.83	1.00E-03			3	OP + LMT	3.32E-09	0%	2F
				0.62		4	Vented	2.97E-07	1%	7F
			0.999		0.7	5	Vented	1.28E-07	1%	7F
		SBO 0.12		0.38	0.3	6	LMT	5.47E-08	0%	3F
	internal 0.2			0.62		7	OP	2.98E-10	0%	6F
			1.00E-03	0.38		8	OP + LMT	1.82E-10	0%	2F
		bypass				9	OP + LMT	2.00E-07	1%	2F
		0.05			0.7	10	Vented	2.80E-08	0%	7F
2.00E-05		fast	0.999		0.3	11	LMT	1.20E-08	0%	3F
		0.01	1.00E-03			12	OP + LMT	4.00E-11	0%	2F
					0	13	Vented	0.00E+00	0%	7F
		other	0.999		1	14	LMT	1.52E-05	76%	3F
	external	0.95	1.00E-03			15	OP + LMT	1.52E-08	0%	2F
	0.8	bypass				16	OP + LMT	8.00E-07	4%	2F
		0.05						CCFP =	86%	

Example Results of Quantitative Uncertainty Analysis (Offsite Cost)

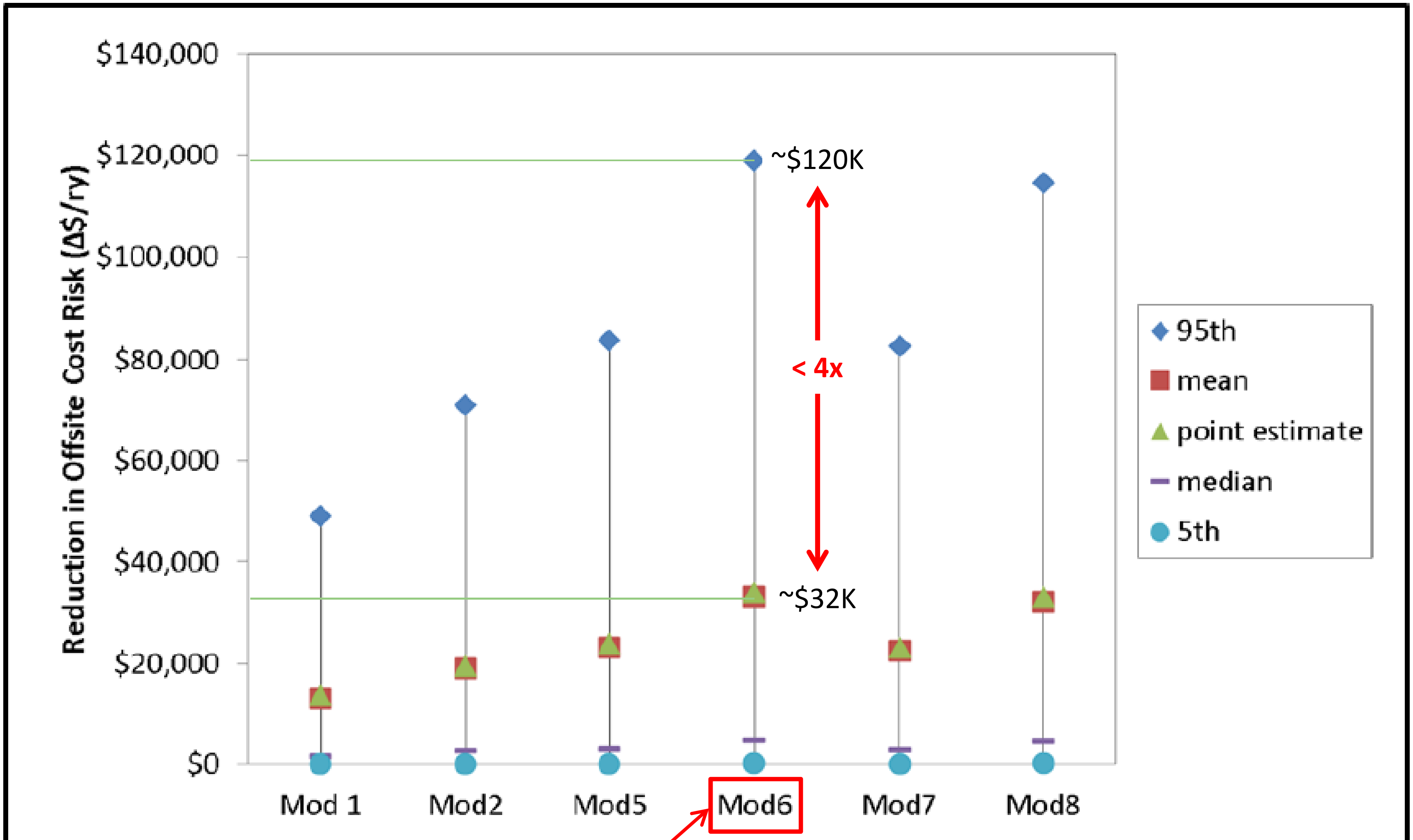

Figure 10. Uncertainty in the reduction in offsite cost risk

Option 3

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Ref.: Enc. 5c, SECY 12-0157