Programme Area: Nuclear

Project: Natural Hazards Review

Title: Presentation - Review of Natural Hazards Project

Abstract:

This presentation in powerpoint format was developed EDF (R&D UK) as the delivery organisation for this project. It was used to share the scope and learning of this project at the members dissemination event at the Royal Academy of Engineering on Wednesday 17th September.

Context:

The Natural Hazards Review project will develop a framework and best practice approach to characterise natural hazards and seek to improve methodologies where current approaches are inefficient. This is to improve energy system infrastructure design and the project is intended to share knowledge of natural hazards across sectors. The project will be completed in three stages. Phase one will focus on a gap analysis. Phase two will look at developing a series of improved methodologies from the gaps identified in phase one, and phase three will demonstrate how to apply these methodologies. Finally, phase 3 will develop a "how to" guide for use by project engineers.

Review of Natural Hazards Project

Pietro Bernardara, CTO, EDF Energy R&D UK Centre Expert on Natural Hazards

Outline

Introduction
- Definitions
- The context
- The project
- The consortium

Part 1 (40 min)
- Literature Review
- Existing gaps and why we need to address them

Part 2 (40 min)
- The way forward for effectively address these gaps (Phase 2)
- Toward a final high quality “how to” Guide

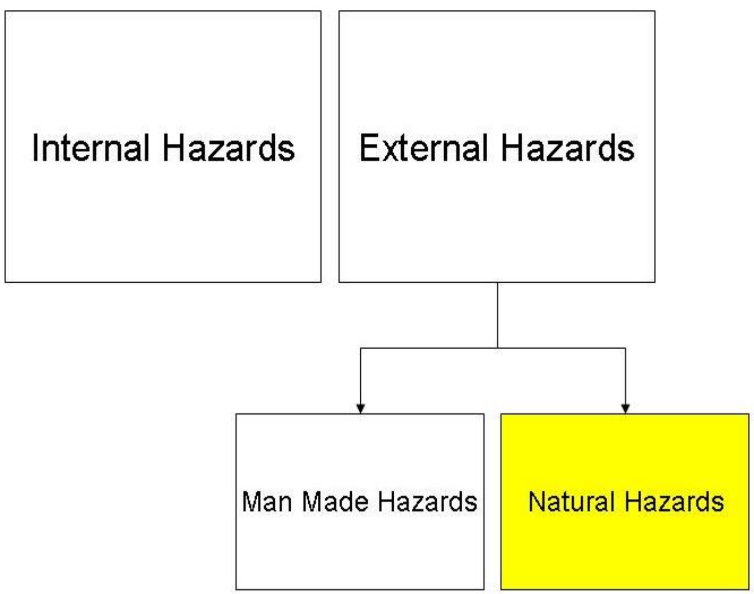
Part 1 – Literature Review

Definitions

> Natural hazard: “an element of the physical environment, harmful to man and caused by forces extraneous to him” (Meteorological, Ocean, Seismic and Volcanic, etc.)

> Geographical scope: “infrastructure based on UK land and offshore waters”

> High value infrastructure: “the energy sector’s infrastructures, including generation and extraction sites, networks and grid”



The context

Some facts

- Japanese Tsunami
- Several storms last winter (i.e. 2 m surge @ East Anglia 5th dec 2013)
- The climate change
- Headlines of the Media

UK Challenges

- New Infrastructures including power generation, CO_2 transport and storage systems to be built

Need Standard approach

- Encompass a full range of natural hazards
- Be ready to use for engineers
- Be high quality

In order to

- Optimize design to reduce the risk of expensive mid-life engineering works
- Allow operating high value infrastructure cost effectively
- Satisfy scheme developers, financiers and industry specific standards and regulation

Context

- Different sectors and different hazards treated separately
- Lack of a engineering focus “how to” guide encompassing all the range of Natural Hazards. Lot of academic and scientific paper.
- Wide uncertainty in the actual prediction and estimation of extreme events intensity

ETI optimal position to support that

The project

Overall Goal: produce a high quality standard approach for the characterization of a large rage of Natural Hazards relevant for high value infrastructure design in the UK

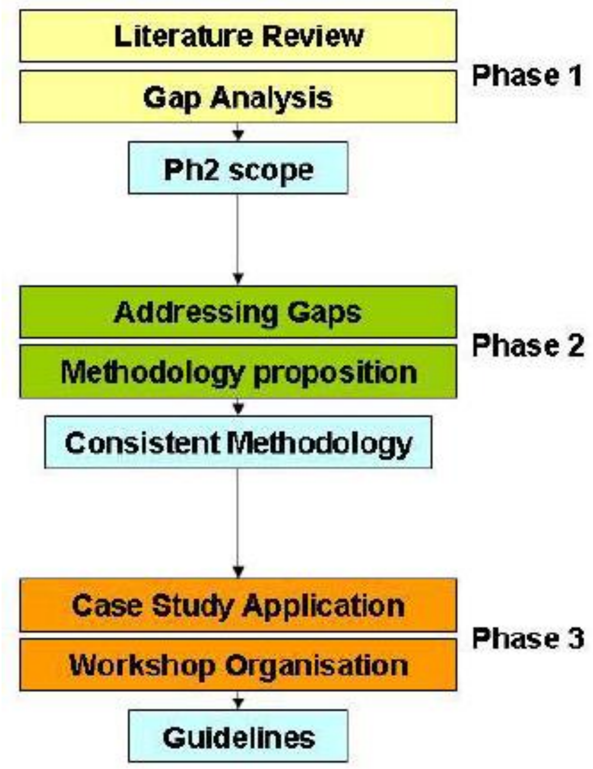
Scope of Phase 1: review of the available methodologies for characterisation of natural hazards and existing gaps

Scope of Phase 2: Addressing gaps and build an high quality methodology proposition

Scope of Phase 3: Deliver, Illustrate, disseminate the "how to" guidelines

Value
- Cost effective design
- Cost effective operation
- ETI members intelligent will be customers

Consequences of not addressing the gaps
- over or under design, leading to potential cost for expensive mid-life modifications
- weak or partial design safety case leading to less interest on investment
- poor operator procedure leading to maintenance, interruption and recovery costs
- poor "how to" guide



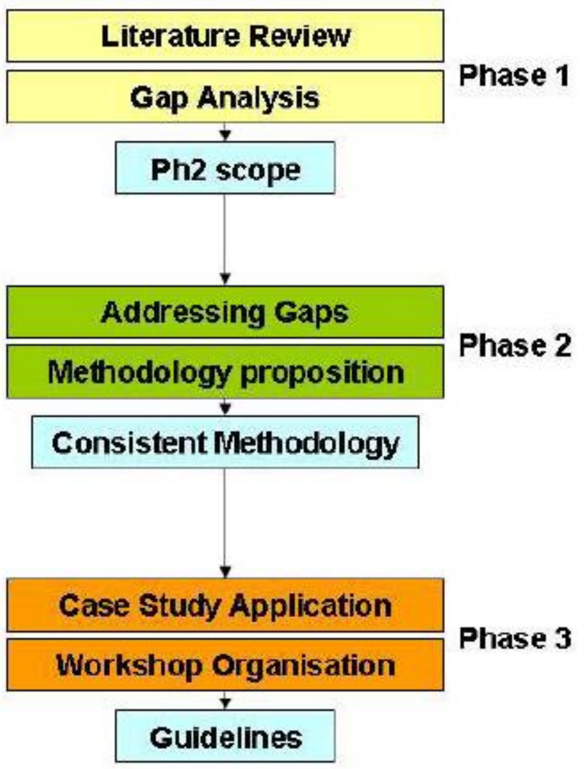
The project

We will show that Phase 1 is done with high quality highly promising results

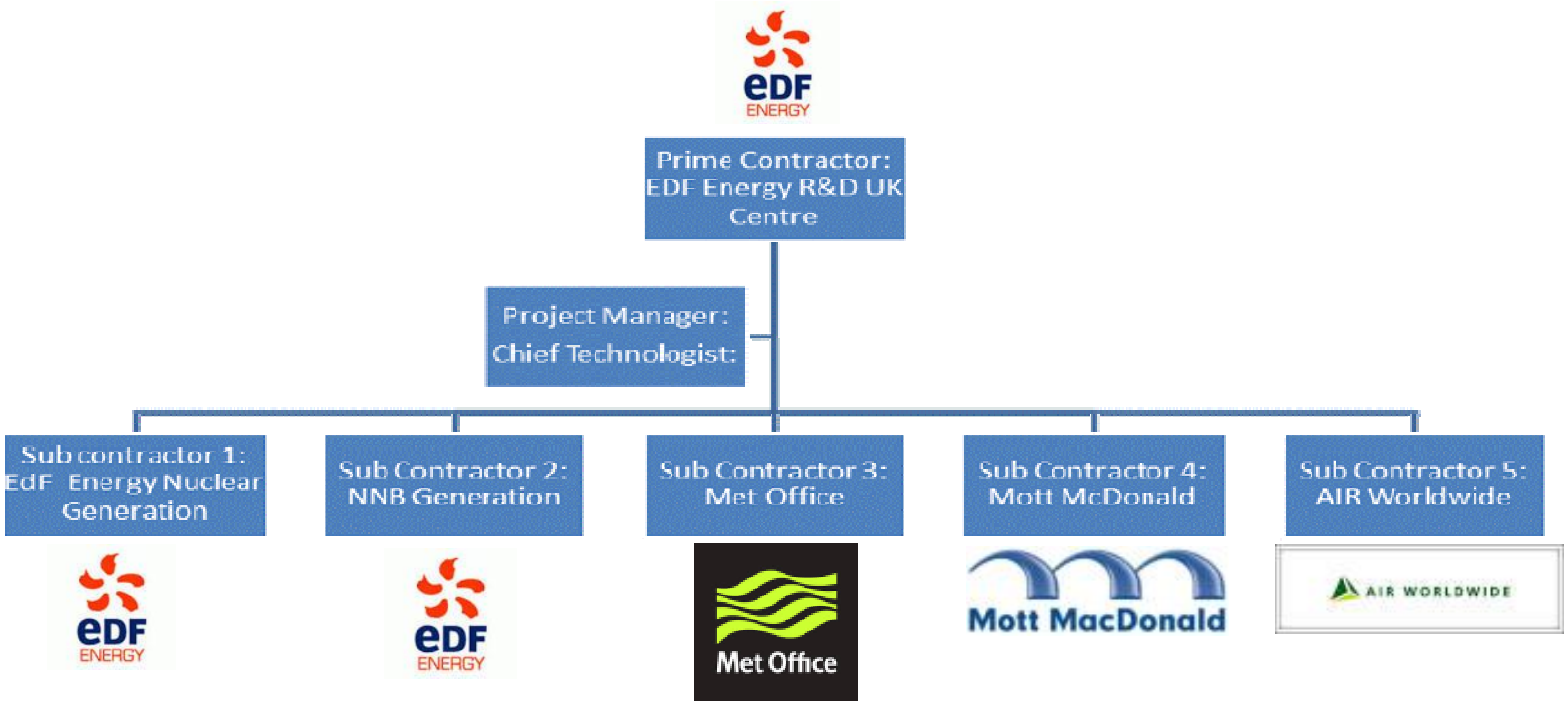
> A high credibility consortium was created to delivery an high quality result

> Literature review was done and gaps were identified to be addressed

> proposal for addressing these gaps in Phase 2 is defined



The consortium

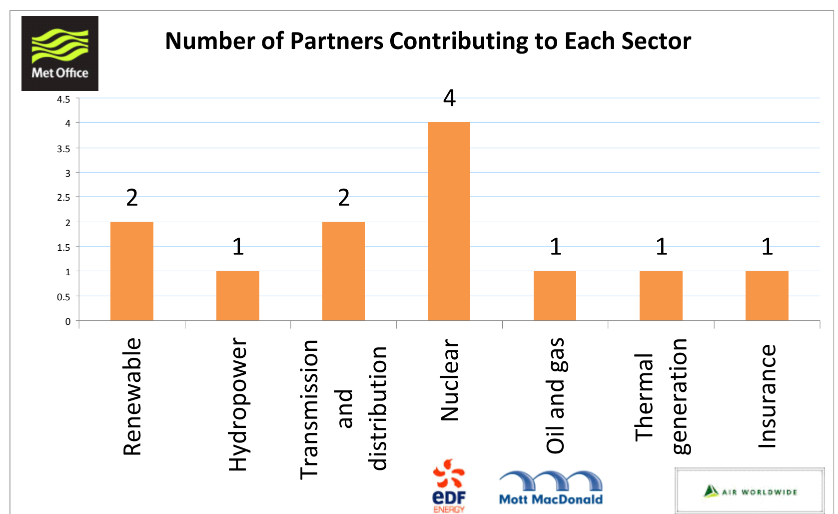


EDF Energy
- R&D division
- Nuclear Generation
- Nuclear New Build Gen. Co.

Met Office

Mott MacDonald

Air Worldwide



Part 1 – Literature Review

The list of hazards

Meteorological	1	Rainfall
	2	Frazil
	3	Extreme and rapid changes in temperatures
	4	High air temperatures
	5	Low air temperatures
	6	High water temperature
	7	Low water temperature
	8	Snow
	9	Wind
	10	Tornadoes
	11	Lightning
	12	Hailstones
	13	Humidity
Marine	14	High sea level
	15	Surge
	16	Waves
	17	Tsunami
	18	Low sea level
Hydrogeological	19	River flood
	20	Flood due to dam failure
	21	Drought
	22	Extreme groundwater level
Geological	23	Offshore Landslide
	24	Sediment trasport
	25	Geological changes
	26	Sandstorms
	27	Earthquake
Biological	28	Marine biological hazard
	29	Animals
Electromagnetic	30	Space Weather
	31	Solar UV
Combinations	32	Hazard Combinations
Other	33	Forest fire
	34	Meteorite impact






Part 1 – Literature Review

Results

> A list of natural hazards

> Available mature methodologies as well as expert judgement regarding the methodology

> Comments on the impact climate change has on natural hazards

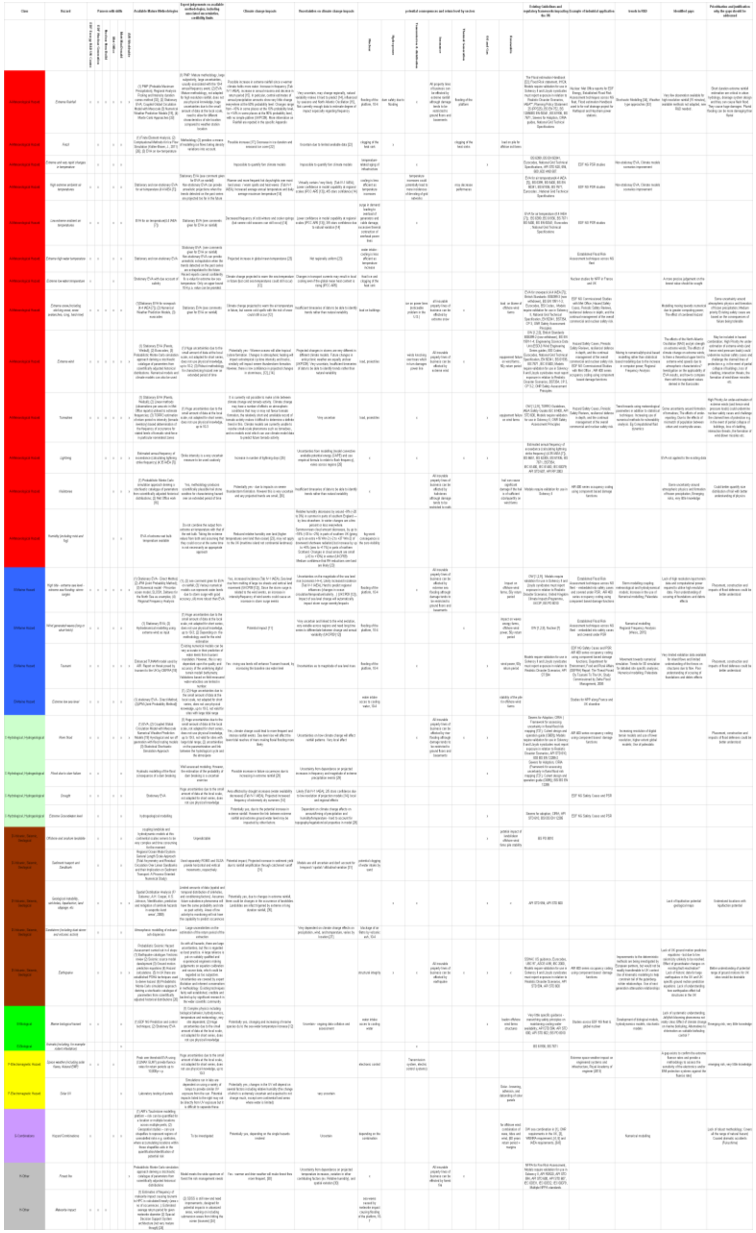
> Analysis of the sectors impacted by each natural hazard and examples of industry applications

> A list of existing guidelines and regulatory frameworks impacting the UK

> Trends in R&D

> Identified Gaps

> Prioritization of the Gaps



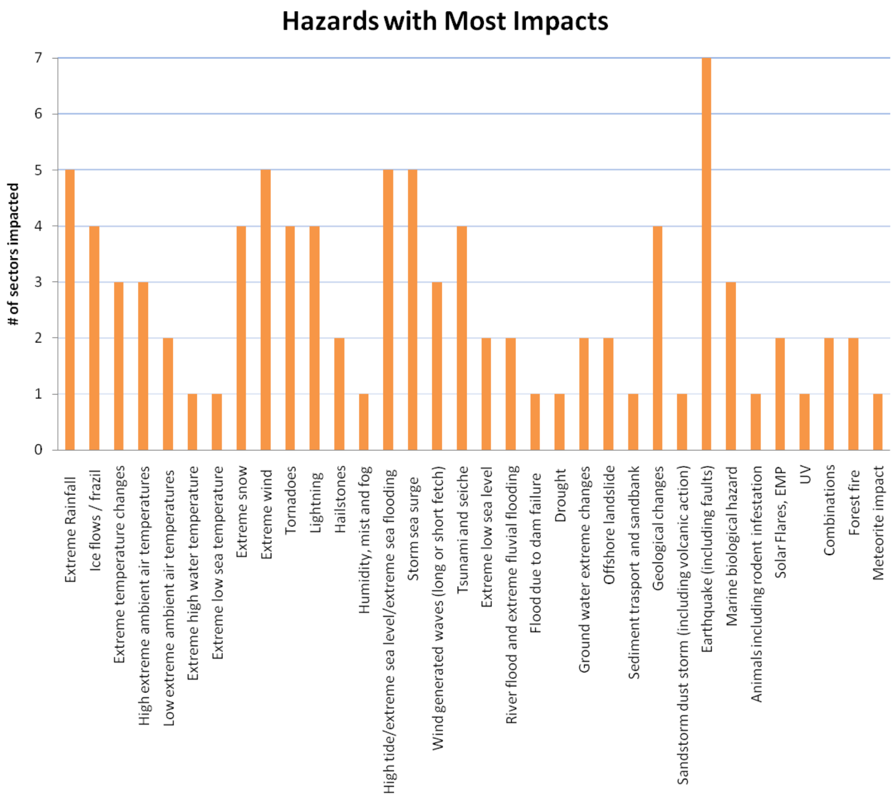
Part 1 – Literature Review

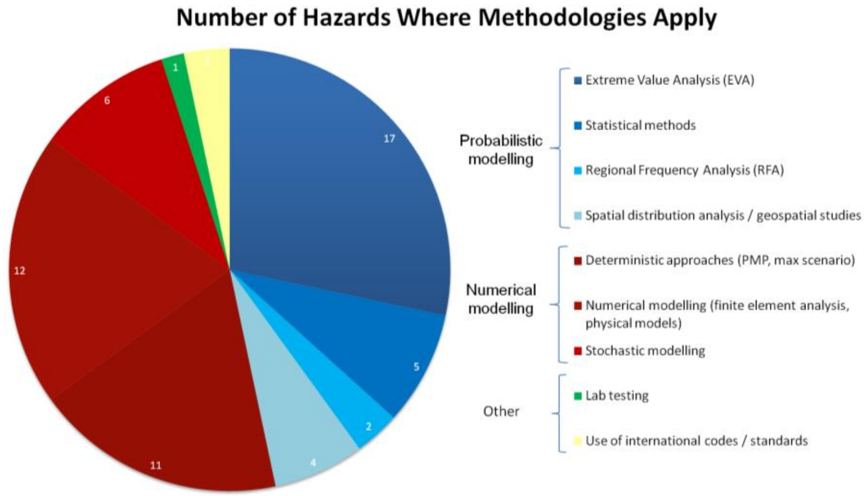
Example

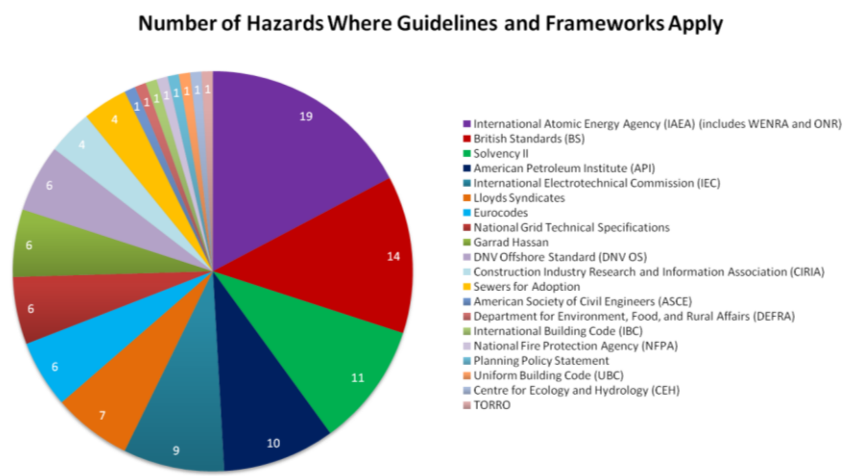
Class	Hazard	Parners with skills						Available Mature Methodologies	Expert judgements on available methodologies, including associated uncertainties, credibility limits	Climate change impacts	Uncertainties on climate change impacts	potential consequences and return level by sectors						
		EDF Energy R&D UK Centre	EDF Nuclear Generation	Nuclear New Build	Met Office	Mott MacDonald	AIR Worldwide					Nuclear	Hydropower	Transmission & distribution	Insurance	Thermal Generation	Oil and Gas	Renewable
A-Meteorological Hazard	*Extreme Rainfall*	x	x	x	x	x	x	(1) PMP (Probable Maximum Precipitation); Regional Analysis Pooling and Intensity duration curves method [32]; (2) Stationary EVA; Coupled Global Circulation Model with Meoscale (3) Numerical Weather Prediction Models [19], (4) Monte Carlo Approaches [33]	(1) PMP: Mature methodology, large subjectivity, large uncertainties, usually associated with the 10-4 annual frequency event; (2) EVA: Mature methodology, not adapted for high resolution rainfall, does not use physical knowledge, huge uncertainties due to the small amount of data at the local scale, need to allow for different characteristics of site location compared to weather station location	Possible increase in extreme rainfall since a warmer climate holds more water. Increase in frequency (Tab IV-1 IAEA), increase in annual maxima and decrese in return period [15]. In paticular, central estimates of annual precipitation amounts show very little change everywhere at the 50% probability level. Changes range from –16% in some places at the 10% probability level, to +14% in some places at the 90% probability level, with no simple pattern (UKPC09). More information on Rainfall are repoted in the specific Appendix	Very uncertain, may change regionally, natural variability makes it hard to predict [14], influenced by seasons and North Atlantic Oscillation [15], Not currently enough data to estimate degree of impact especially regarding frequency	flooding of the platform, 10-4	dam safety due to flooding	x	All property lines of business can be effected by extreme rainfall although damage tends to be restricted to ground floors and basements	flooding of the platform		

Existing Guidelines and regulatory frameworks impacting the UK	Example of industrial application	trends in R&D	Identified gaps	Prioritisation and justification why the gaps should be addressed
The Flood estimation Handbook [32]; Flood Risk statement, IH124; Models require validation for use in Solvency II and Lloyds synidcates must report exposure in relation to Realistic Disaster Scenarios, IAEA**, Planning Policy Statament 25 (PPS25), BS EN 752, BS 12056BS EN 50341, BS 61936, BS 7671, Sewers for Adoption, CIRIA guides, National Grid Techical Specifications	Nuclear: Met Office reports for EDF Energy, Established Flood Risk Assessment techniques across NG fleet, Flood estimation Handbook used to for roof drainage project for Hartlepool and Heysham power stations.	Stochastic Modelling [34], Weather type approaches [33]	Very few observation available for high resolution rainfall (15 minutes), available methods not adapted, new R&D needed .	Short duration extreme rainfall estimation are critical in urban hydrology, drainage system design and they can cause flash flood. They cause huge damages. Pluvial flooding can be more damaging than fluvial

Part 1 – Literature Review







"Confidence in numerical models can be high, if the appropriate model is being used. […]. EVA can also yield useful results if the extremes are not extrapolated too far […]. Both methods are models, not reality, and should always be treated as such"

AIR WORLDWIDE

Part 1 – Existing gaps

Meteorological
1. High resolution rainfall
2. Extreme winds
3. Low water temperature
4. Lightning
5. Hailstones
6. Tornado

Marine
7. Tsunami

Volcanic, seismic, and geological
8. Earthquake
9. Liquefaction
10. Volcanic ash

Biological
11. Biological clogging

Electromagnetic
12. Space Weather

Combinations
13. Hazard combinations

General Gaps
14. Numerical modelling
15. The impact of climate change

Wind: The effect of climate change? Upper limit? Differences between EVA and Eurocodes?

Part 1 – Existing gaps

Objective:

> Prioritize a maximum of 5 gaps to be addressed

Criteria:

> Industrial prioritization

Is the gap important in an industrial point of view? Which is the prioritization of this gap from the industrials partners

> Impacts

Does the gap need to be solved quickly in order to avoid industrial risk or in order to optimize industrial procedures?

> Scientific community prioritization

Does the gap represent an important lack of scientific knowledge on the phenomena comprehension or modelling? Is the scientific community carrying out programs on that gap?

> Feasibility on the project timescale

Is that reasonable to solve the gap within the timescale and the budget of the ETI Phase 2 program?

> Transferability to the “how to” guide

Is that reasonable to suggest an "how to do" procedure and to make the results available for industrial applications within the timescale and the budget of the ETI Phase 2 program?

Part 1 – Existing gaps

1. Hazard combinations
2. Extreme winds
3. High resolution rainfall — Scientific community carrying out programs on that gap (NERC, EPSRC)
4. Hailstones
5. Lightning
6. Biological clogging
7. Space Weather
8. Low water temperature — Lower impact than the others
9. Earthquake
10. The impact of climate change — Scientific community carrying out programs on that gap
11. Numerical modelling — Low feasibility at the project timescale
12. Volcanic ash — Scientific community carrying out programs on that gap (NERC)
13. Tornado
14. Liquefaction
15. Tsunami

1	**Hazard combinations**	203	50	34	45	34	40
2	**Extreme winds**	202	30	42	50	30	50
3	**High resolution rainfall**	195	38	28	42	42	45
4	**Hail**	188	42	40	40	32	34
5	**Ligthning intensity**	187	45	36	38	38	30
6	**Biological**	184	38	45	32	45	24
7	**Space weather**	180	40	50	36	26	28
8	**Low sea temperature**	158	32	38	34	28	26
9	**Earthquake**	142	28	32		50	32
10	**Climate Change**	128	22	30		40	36
11	**Numerical modelling**	82	18	26			38
12	**Volcanic ash**	70	38		32		
13	**Tornadoes**	26	26				
14	**Liquefaction**	24	24				
15	**Tsunami**	20	20				

Part 1 – Existing gaps

> Industrial prioritization
> Impacts
> Scientific community prioritization
> Feasibility on the project timescale
> Transferability to the “how to” guide

Hazard Combination

Hazard combinations may generate a large range of issue to high value infrastructure and power plant. Example: Fukushima accident

However, a clear understanding of the actual probability of simultaneous occurrences of coupled hazards is not always available. Moreover there is no one widely accepted consensual approach

The risk for not address this gaps is that potential combination of natural hazard may remain unknown, preventing to reduce the risk by mitigation measure or appropriate design. The failure in addressing quickly this gap may lead as well to over or under design requiring expensive mid-life modifications

Hail

Hailstones may damage building roofs and infrastructures by the impact of hailstones and hail load.

Lack of a robust methodology for hailstones characterisation

Not addressing this gap prevents an actual estimation of the maximum hailstones size and loads and thus increasing the risk of over or under design.

Part 1 – Existing gaps

> Industrial prioritization
> Impacts
> Scientific community prioritization
> Feasibility on the project timescale
> Transferability to the “how to” guide

Lightning

Lightning strikes may damages power lines, electric devices. The impact may be direct, causing structural damage or indirect through an electromagnetic feeder fire started by lightning. Example: Egypt, 1994: a lightning incident lead to the explosion of fuel tanks, 469 fatalities

The worst lightning strike (peak current, half life, charge, energy) is difficult to estimate because of the lack of reliable measure for lightning intensity means that extreme lightning estimations are very uncertain. Only strike frequency is known.

Not addressing this gap is increasing the risk of over or under design

Biological Clogging

Biological materials transported by water or excessive growth of algae and seaweed may clog up the water intake of power plants or damages marine structures

However, the blooming of marine biological species and the actual parameters driving this phenomenon are not completely understood

If not addressed the risk of observing clogging of power plant water intake and damage on off shore infrastructure can not be reduced by early warning, appropriate mitigation measures and adapted design

Space Weather

Geomagnetic disturbances (GMDs) – severe solar storms that induce large currents in the electric grid on Earth have the potential to damage expensive equipment and result in widespread blackouts. Examples (Quebec black out 1989)

A gap exists regarding the understand of the risks posed by these storms and the estimation of the intensity of an extreme space weather event

If not this gap addressed the existing risk of damage on electric control system can not be reduced by appropriate mitigation measures and adapted design allowing these events to potentially wreak long-term havoc on a large section of the population and the economy,

Part 2 – The way forward

	Q1 2015			Q2 2015			Q3 2015			Q4 2015		
	Jan '15	Feb '15	Mar '15	Apr '15	May '15	Jun '15	Jul '15	Aug '15	Sept '15	Oct '15	Nov '15	Dec '15
Natural Hazards Phase 2												
Task 1: Hazard combination												
Task Managament												
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R&D Summary Report									D1.1			
Industrialisation Plan											D1.2	
Internal Technical/QA review				R1.1			R1.2			R1.3		
Task 2: Biological clogging												
Task Managament												
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Internal Technical/QA review						R2.1		R2.2		R2.3		
Task 3: Space Weather												
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R&D Summary Report						D3.1						
Industrialisation Plan									D3.2			
Internal Technical/QA review				R3.1		R3.2			R3.3			
Task 4: Hail												
Task Managament												
Task Kick Off Workshop (Define methodologies/toolkit of relevance)												
Research & Development (R&D)												
R&D Summary Report									D4.1			
Industrialisation Plan											D4.2	
Internal Technical/QA review							R4.1			R4.2		
Task 5: Lightning												
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R&D Summary Report							D5.1					
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Task 6: Case study selection for Phase 3 & planning												
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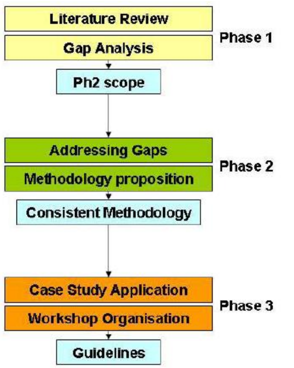
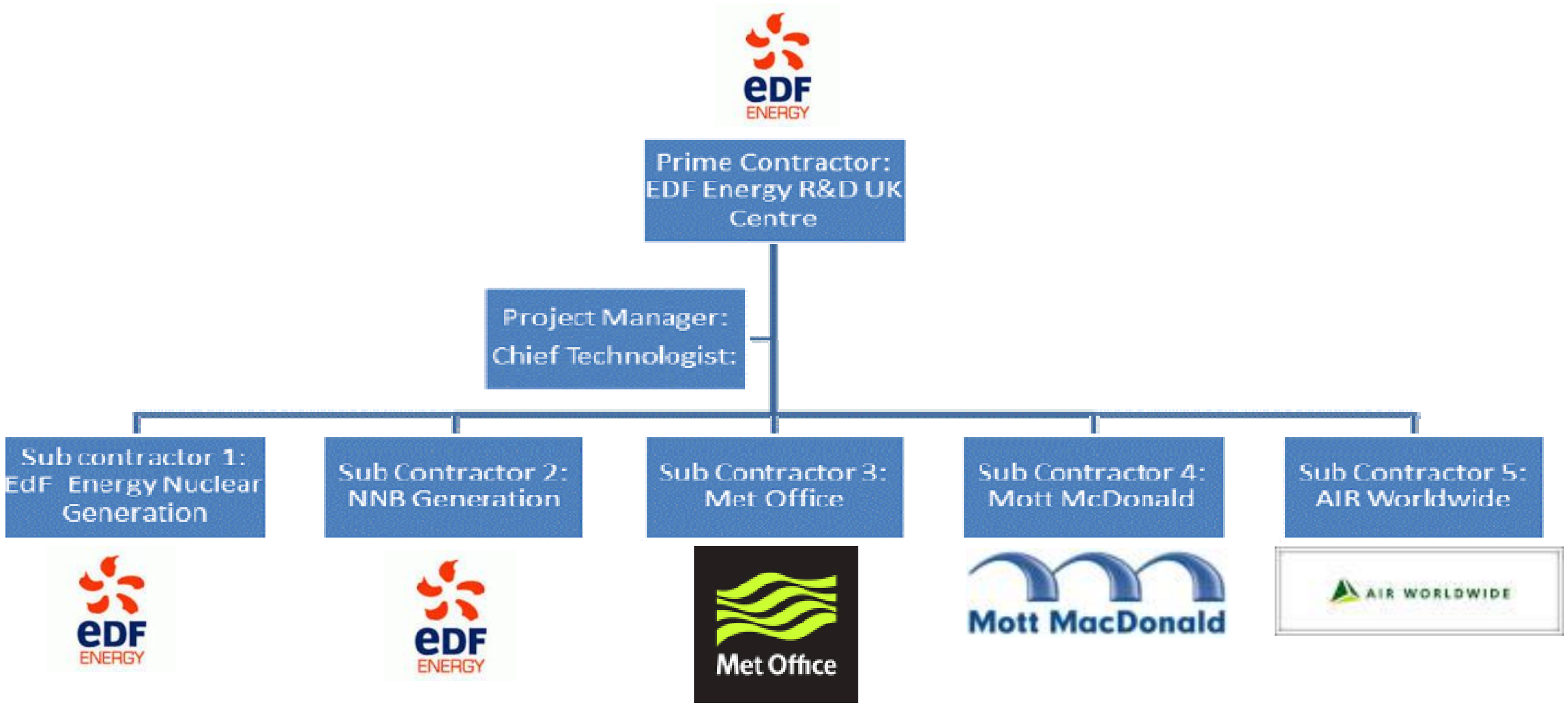
Finalise case study												
Technical Review (ETI and the Project)											R6.1	
Report												D6.1
Task 7: Project Management and Reporting												
Project management (plans, risks, issues, quality assurance)												
Quarterly project meetings with the ETI including Kick off												
Regular meeting and Monthly Project Steering Committee Meetings												
Monthly progress reports	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1	D7.1
Technical Review meetings (ETI and the Project)						R7.1				R7.2		
Presentation to ETI												D7.2



Part 2 – The way forward



Part 2 – The way forward

Hazard Combination

Goal: to deliver a summary of the extent to which a selection of the hazards listed in D1 of the Phase 1 could potentially occur in combination, together with a list of methodological suggestions (quantitative or qualitative approaches) to estimate the likelihood of occurrence of each combination.

D 1.1: A qualitative assessment of the extent to which a given selection of hazards could occur in combination with each other

D 1.2: “How to” on the characterization of hazard combination

Duration: 12 months

Expected budget around £100k

Project Manager & CTO : EDF Energy R&D UK Centre

Skills: Meteorology (Met Office), probability (EDF Energy R&D UK Centre), industrialization (EDF Energy, Mott MacDonald)

Hail

Goal: to provide a reliable approach to estimate the nature of extreme hail hazard for the UK

D 2.1: Report including an estimation of the extreme hail hazard over the UK

D 2.2: “How to” on the characterization of hail

Duration: 9 months

Expected budget around £60k

Project Manager & CTO : EDF Energy R&D UK Centre

Skills: Meteorology and observations (Met Office), numerical modelling (AIR Worldwide), Industrialization (EDF Energy, Mott MacDonald)

Part 2 – The way forward

Lightning

Goal: to provide a reliable approach to estimate the nature of extreme lightning hazard for the UK

D 3.1: Report including an estimation of the extreme lightning hazard over the UK. Suggested duration: 4 months. Suggested resources: 3

D 3.2: “How to” on the lightning characterisation

Duration: 9 months

Expected budget around £50k

Project Manager & CTO : EDF Energy R&D UK Centre

Skills: Meteorology and observations (Met Office), probability (EDF Energy R&D UK Centre), industrialization (EDF Energy, Mott MacDonald)

Biological Clogging

Goal: to provide a basis for the understanding of the hydrodynamic mechanism and the biological phenomena leading to the occurrence of jellyfish and seaweed, impacting the intake and the off shore facilities in the UK waters

D 4.1: Report including the list of species, their biological behaviour, the sources of the species and the map of the potential path for the UK waters.

D 4.2 “How to” on the biological clogging characterisation

Duration: 9 months

Expected budget around £50k

Project Manager & CTO : EDF R&D UK Centre

Skills: Meteorology and ocean sciences (Met Office & external potential partners HRW or CEFAS), biology (EDF Energy R&D UK Centre & external potential partners HRW or CEFAS or Fawley Acquatic), industrialization (EDF Energy, Mott MacDonald)

Part 2 – The way forward

Space Weather

Goal: to provide a basis for the understanding of the potential impact of a solar storm on the electric system and a first estimation of an extreme scenario for the UK.

D 5.1: Report including the description of extreme space weather events and their impact. A definition of a credible extreme scenario will be included.

D 5.2: "How to" on the space weather characterisation

Suggested duration: 9 months.

Expected budget around £60k

Project Manager & CTO : EDF R&D UK Centre

Contributions: Space weather (Met Office, Air Worldwide), industrialization (EDF Energy)

Part 2 – The way forward

Skills

Partners	Project Management	R&D Management	Industrial Expertise / End User	TQA	R&D Expertise					
					Meteorology	Probability	Numerical	Biology	Ocean Sciences	Space Weather
EDF Energy R&D UK Centre	X	X				X		X	X	X
Met Office	X	X	(X)	X	X	X	X	(X)	X	X
AIR Worldwide					X	X	X			X
EDF Energy NG			X	X		X		X	X	X
NNB Gen.Co.			X	X		X		X	X	X
Mott MacDonald	X		X	X						
New Academic Partner								X	X	

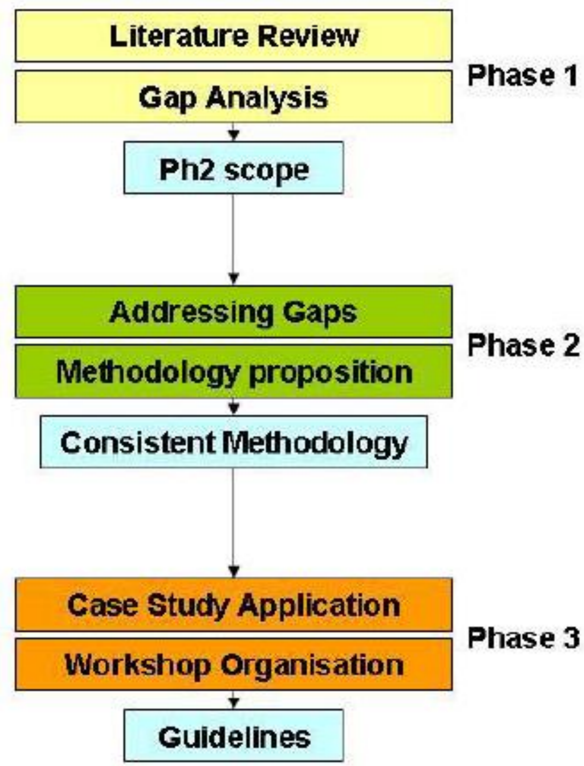
Toward a final high quality "how to" guide

Status of the project

Phase 1
D1 Literature review and gap analysis ☺Done
D4 Phase 2 scope ☺Done
Budget £50k

Phase 2
Good shape ☺
Contract: Expected November 2014
Delivering: January to December 2015
Expected budget : £300k-£400k

Phase 3
Anticipated in Phase 1 proposal ☺
Delivering: June to December 2016
Expected budget : £150k



	Q3 2016			Q4 2016		
	Jul '16	Aug '16	Sept '16	Oct '16	Nov '16	Dec '16
Natural Hazards Phase 3						
Selection of worked example case studies	■					
Definition and characterisation of baseline design target	■	■				
Undertake full natural hazard assessment on case studies		■	■	■		
Development of written worked examples				■	■	
Preparation of 'how to' guide					■	
Workshop					■	
Development of publishable version of 'how to' guide						■
Project management	■	■	■	■	■	■
Steering Group meetings	■				■	
ETI monthly report	■	■	■	■	■	■

Part 2 – The way forward

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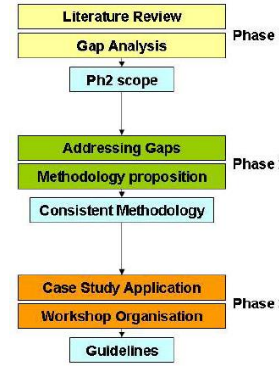

EDF Energy R&D UK Centre

Thank you! Questions? Comments?