

## Post Fukushima Research at GRS

24th Annual Regulatory Information Conference (RIC)  
Washington  
13-15 March 2012  
Frank-Peter Weiss, Thomas Schimpfke

---

---

---


---

---

---

---


---



### Introduction (1)

**GRS continuously tracks the progression of the accident**

- GRS Emergency Center operated for about two month after accident initiation
- Efforts:
  - 50 persons were involved at GRS
  - 200 information notices and short notes were published
  - 700 press requests, 20 TV interviews, ~ 4,5 Million visits at GRS Internet-portal
- GRS tracks
  - the measures taken at the Fukushima Dai-ichi NPP
  - the radiological situation.



Post Fukushima Research at GRS; RIC 2012 2

---

---

---


---

---

---

---

---



### Introduction (2)

**GRS provided interim report**

- **Interim report about course of accident and consequences**
  - **Preliminary findings**
    - External hazards were underestimated in the design of the plant
    - Long lasting loss of power supply and of ultimate heat sink (UHS) obviously not taken into account in the specification of accident management (AM) measures
    - Potential damages of infrastructure not sufficiently considered in planning the AM
  - **Open questions related to the detailed course of the accident, e.g. to**
    - Hydrogen escape paths from the Primary Containment Vessel (PCV)
    - Possible Hydrogen generation in SFP
    - Final states of core and RPV
    - Feasibility and effectivity of AM measures taken by plant staff
- **Need for more detailed investigations to understand the accident and to derive implications for German NPPs**

Post Fukushima Research at GRS; RIC 2012 3

---

---

---

---

---

---

---

---

**GRS**

**Introduction (3)**

**Two GRS post Fukushima research projects**

- **Funding:**
  - **BMU** (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
  - **BMWi** (Federal Ministry of Economics and Technology)
- **Total financial volume:** 3,4 M€ (BMU) and 0,9 M€ (BMWi)
- **Main focus**
  - **BMU:**
    - In-depth analysis of Fukushima event sequence: external events, loss of electrical power supply, organizational matters, AM measures
    - Implications to German NPPs: e.g. in respect to AM measures
  - **BMWi:**
    - Review of modeling and simulation capacity with respect to phenomena, which occurred during Fukushima accident, closure of gaps if necessary
- **Duration:** 3 years starting in September 2011

Post Fukushima Research at GRS; RIC 2012 4

---

---

---

---

---

---

---

---

---

---

---

---

**GRS**

**BMU funded post Fukushima research project (1)**

**Working Program (selected tasks)**

1. In-depth investigation of accident and phenomena
2. Thermal-hydraulic analyses (ATHLET-CD/COCOSYS)
3. Response to natural external hazards
4. Vulnerability of electrical power supply
5. Analysis of Accident Management measures
6. Investigation of Cliff-Edge effects in AM
7. Organizational factors in emergency management
8. Development of methods for assessment of decision making processes
9. Adaptation of FMEA for cable fire to flooding events

Post Fukushima Research at GRS; RIC 2012 5

---

---

---

---

---

---

---

---

---

---

---



---

**GRS**

**BMU funded post Fukushima research project (2)**

**1. In-depth investigation of accident and phenomena**

- Collection of information on plant design, design base loads, natural impact and course of the accident (collaboration with JNES)
- Detailed data analysis:
  - "reconstruct" the accident sequence
  - identification of key events and major phenomena occurred

Post Fukushima Research at GRS; RIC 2012 6

---

---

---

---

---

---

---

---

---

---

---

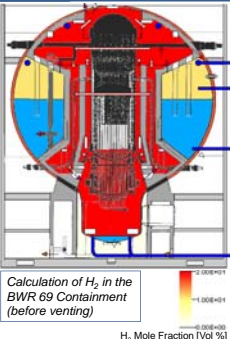
---

GRS

**BMU funded post Fukushima research project (3)**

**2. Thermal-hydraulic analyses (ATHLET-CD/COCOSYS)**

- "Fukushima-like" model based on BWR 69 with boundary conditions from accident analysis
- Analysis of different accident phases with regard to H<sub>2</sub> generation and to radioactive source term
- Assessment of relevance for German NPPs by calculating the behaviour of a German PWR exposed to a similar hazard



Calculation of H<sub>2</sub> in the BWR 69 Containment (before venting)

H<sub>2</sub> Mole Fraction [Vol %]

Post Fukushima Research at GRS; RIC 2012

7

---

---

---

---

---

---

---

---

---

---

---

---

GRS

**BMU funded post Fukushima research project (4)**


**3. Response to natural external hazards**

- Study transferability of earthquake and flooding impacts (combination + fire) to German NPPs: general specification of beyond design nat. hazards
- Analysis of the protection of German NPPs against beyond design impacts
- Recommendations to improve protection in case of weaknesses identified



**4. Vulnerability of electrical power supply**

- Analysis of layout of Japanese electrical grid
- Analysis of consequences of earthquake, tsunami to the power and emergency power supply
- Assessment of the behaviour of power supply in German NPPs under analogue conditions
- Recommendations for German grid and emergency power supply if necessary



Post Fukushima Research at GRS; RIC 2012

8

---

---

---

---

---

---

---

---

---

---

---


---

GRS

**BMU funded post Fukushima research project (5)**


**5. Analysis of Accident Management measures**

- Assessment of feasibility and effectiveness of AM measures in German NPPs under Fukushima-like conditions (long lasting SBO and loss of UHS, damaged infrastructures)
- Identification of weak points and suggestion of possible improvements and extensions



**6. Investigation of cliff-edge effects in AM**

- Dynamic PSA analyses in combination with MELCOR calculations plus uncertainty analysis for a specific scenario at a German PWR
- Identification of grace periods for AM actions (bleeding, feeding, venting) to avoid core damage



Post Fukushima Research at GRS; RIC 2012

9

---

---

---

---

---

---

---

---

---

---

---


---

GRS

**BMU funded post Fukushima research project (6)**


**7. Organisational factors in emergency management**

- Investigation of organisational requirements + structures with regard to their effectiveness at Fukushima NPP and in relation to utility (TEPCO) and authority (NISA)
- Comparison to safety relevant organisation in German NPPs and identification of potential improvements in structures and procedures



**8. Development of methods for assessment of decision making processes**

- Investigation of the effect of factors of influence (e.g. time pressure, information overflow) on communication, collaboration and shared decision making in emergency
- Development of an approach (on the basis of the factors of influence) to assess the adequacy of decisions by the emergency response team



Post Fukushima Research at GRS; RIC 2012 10

---

---

---

---

---

---

---

---

---

---

---

---

GRS

**BMU funded post Fukushima research project (7)**

**9. Adaptation of FMEA for cable fire to flooding events**

- Adaptation of Failure Mode and Effect Analysis methodology (available for fire) to flooding events by analysing damage states of cable and electrical systems in humid or wet environments
- Prerequisite to the prediction of safety relevant consequences of postulated water levels due to internal or external flooding in specific building areas of German PWRs

Post Fukushima Research at GRS; RIC 2012 11

---

---

---

---

---

---

---

---

---

---

---

---

GRS

**BMWf funded post Fukushima research project (1)**

**Critical Review of the modelling of specific phenomena in German SA codes**

- Test of coupled simulation tools ATHLET-CD/COCOSYS with respect to selected SA phenomena (model based on BWR 69)**
  - Cooling of partly molten core and fission product release from core
  - Fission product retention inside the wetwell of BWR plants; pool scrubbing specifically for saturated water conditions
  - Fission product retention in filtered venting
- Structural mechanics analysis of dynamic containment behaviour**
  - Latest PWR type (KONVOI) under beyond design earthquake loads (primary earthquake and aftershock loads)
  - Determination of floor response spectra and loads to components and piping structures

Post Fukushima Research at GRS; RIC 2012 12

---

---

---

---

---

---

---


---

---

---

---

---



**BMW funded post Fukushima research project (2)**

- **Spent fuel pool behaviour during severe accident sequences, application of analytical tools ASTEC and MELCOR**
  - PWRs and BWRs under Station Black-out conditions
  - Two operational cases: 1) starting from normal power operation  
2) core fully unloaded to SFP
  - Phenomena: cooling of partially uncovered FAs , combined cladding oxidation by steam and air, zircon fire, relocation of molten material, fission product release

Post Fukushima Research at GRS; RIC 2012 13

---

---

---


---

---

---

---

---



**Summary and Outlook**

**Post Fukushima Research at GRS is funded by**

- **BMU** to evaluate the transfer of Fukushima lessons learned to German NPPs and by
- **BMW** to review the possible range of application of simulation codes in order to cover further beyond design basis scenarios

**GRS is ready to exchange the results within**

- international collaborations of OECD/NEA and IAEA
- international projects of ETSON partners
- bi-lateral projects with NRC
- EURATOM projects

Post Fukushima Research at GRS; RIC 2012 14

---

---

---


---

---

---

---

---



**THANK YOU !**

Post Fukushima Research at GRS; RIC 2012 15

---

---

---


---

---

---

---

---



**BMU funded post Fukushima research project (1)**

- „Questions on safety and risk after the nuclear accident in Japan“
- 3 Year project (Sept. 2011 – Sept. 2014)
- **Objectives**
  - Clarification and assessment of the accident sequences in Fukushima
  - Identification of possible threats to German NPPs under extreme natural hazards
  - Recommendations to improve measures against and during beyond design conditions
  - Updating of interim report including lessons learned, conclusions, and recommendations

Post Fukushima Research at GRS; RIC 2012 16

---

---

---

---

---

---

---

---