PAUL SCHERRER INSTITUT

PSI

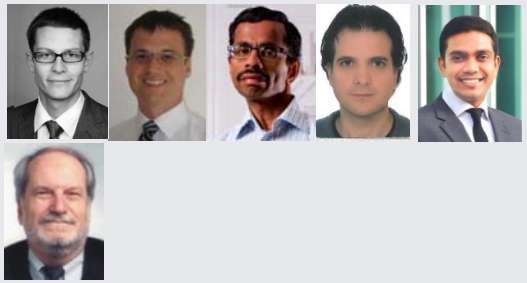
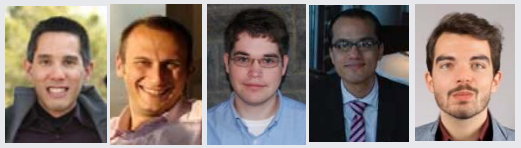
Vinh N. Dang :: Head a.i., Laboratory for Energy Systems Analysis :: Energy Divisions :: PSI

Laboratory for Energy Systems Analysis (LEA)

NES Event, PSI, 24 October 2017

Laboratory for Energy Systems Analysis (LEA)

V.N. Dang (a.i)

Technology Assessment (TA) P. Burgherr	Energy Economics (EE) T. Kober	Risk & Human Reliability (RHR) V.N. Dang
 FRS Risk Group		 FRS Human Performance & Resilience Group 
- **8 scientists** - **2 PhDs** - **1 visiting PhD** **Future Resilient Systems, SG:** - **1 Postdoc** - **2 PhDs** - **1 Software Engineer**	- **4 scientists** - **1 Postdocs** - **1 PhDs** - **1 Honorary Scientist**	- **2 scientists** - **1 Postdoc** - **2 PhDs** **Future Resilient Systems, SG:** - **2 Postdoc** - **1 PhD**

Project Portfolio: Technology Assessment & Energy Economics

Electricity
SCCER SoE (CTI)
SCCER JA S&M (CTI)
Energy Perspectives (SFOE)
Powerdesign (SFOE)
Swisshydro (VSE)
Bi-level El. Markets (SFOE)
ALKAMMONIA (EC)
Swissnuclear LCA (sn)
HTR MSR (PSEL)

Storage
SCCER HaE(CTI)
SCCER JA HaE P2X (CTI)
ISCHESS (CCEM, SER)
AA-CAES (NRP70)
THRIVE (NRP70)
ESI Platform

Energy
Global Energy Scenarios (WEC)
ELEGANCY (EC)
OASES (NRP73)
IDEAS4Cities (CCEM)
INSIGHT-E (EC)
Energy in Swiss Industry (BfE)

Mobility
SCCER Mobility (CTI)
SCCER JA CREST Mobility (CTI)
Electricity-based Mobility (CCEM)

Tools, Databases & Communication
TIMES, STEM, GMM, etc.
ecoinvent
ENSAD
Mighty MCDA
OCELOT
Energiespiegel

Risk Assessment
Future Resilient Systems (SEC, NRF)
Hydropower Accidents (NRP70)
SAMOFAR (EC)
Critical Infrastructure Protection (FOCP)

Health Effects of Technologies for Power Generation: Normal Operation, Severe Accidents & Terrorist Threat Hirschberg et al.

Addressed questions:

- How large are the health effects of various electricity generation technologies and fuel cycles?
- How do health risks from normal operation compare with those resulting from accidents and hypothetical terrorist attacks?
- Which are the major limitations of the current estimates?

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Health effects of technologies for power generation: Contributions from normal operation, severe accidents and terrorist threat

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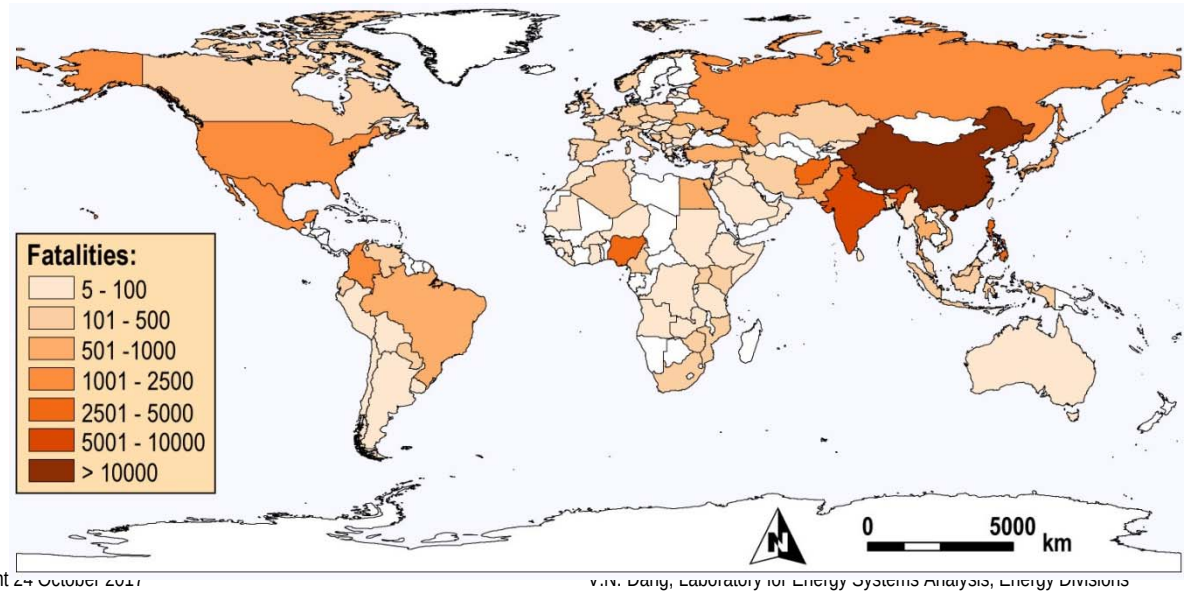
Severe accidents
Terrorist threat
Comparative risk assessment

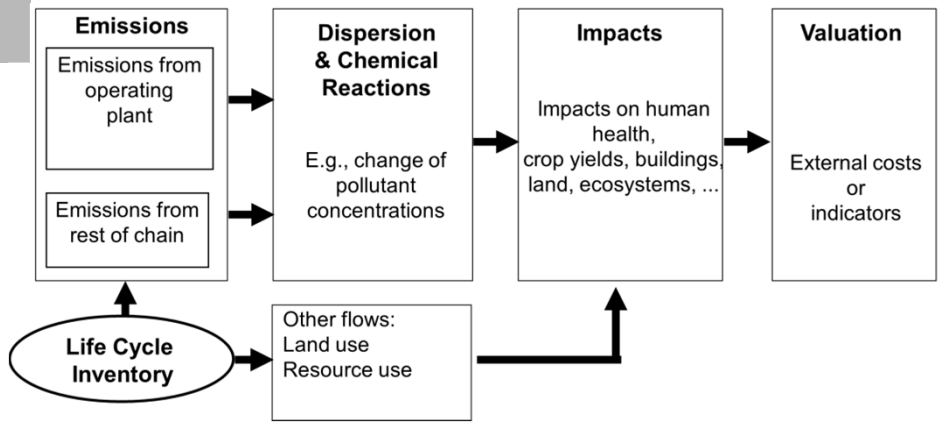
ABSTRACT

As a part of comprehensive analysis of current and future energy systems we carried out numerous analyses of health effects of a wide spectrum of electricity supply technologies including advanced ones, operating in various countries under different conditions. The scope of the analysis covers full energy chains, i.e. fossil, nuclear and renewable power plants and the various stages of fuel cycles. State-of-the-art methods are used for the estimation of health effects. This paper addresses health effects in terms of reduced life expectancy in the context of normal operation as well as fatalities resulting from severe accidents and potential terrorist attacks. Based on the numerical results and identified patterns a comparative perspective on health effects associated with various electricity generation technologies and fuel cycles is provided. In particular the estimates of health risks from normal operation can be compared with those resulting from severe accidents and hypothetical terrorist attacks. A novel approach to the analysis of terrorist threat against energy infrastructure was developed, implemented and applied to selected energy facilities in various locations. Finally, major limitations of the current approach are identified and recommendations for further work are given.

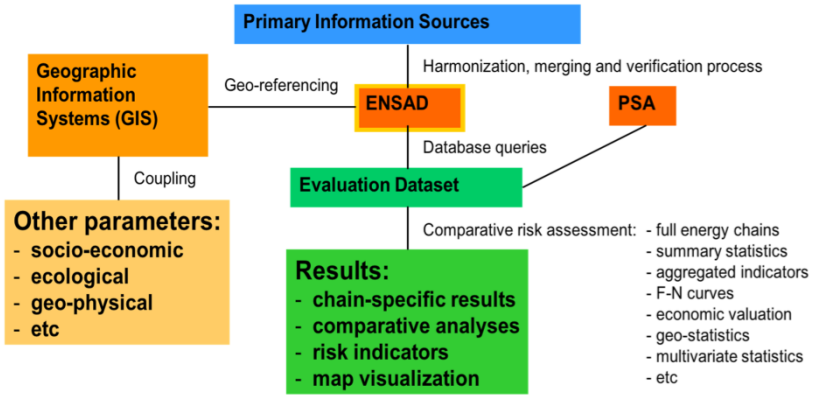


Methodological Frameworks

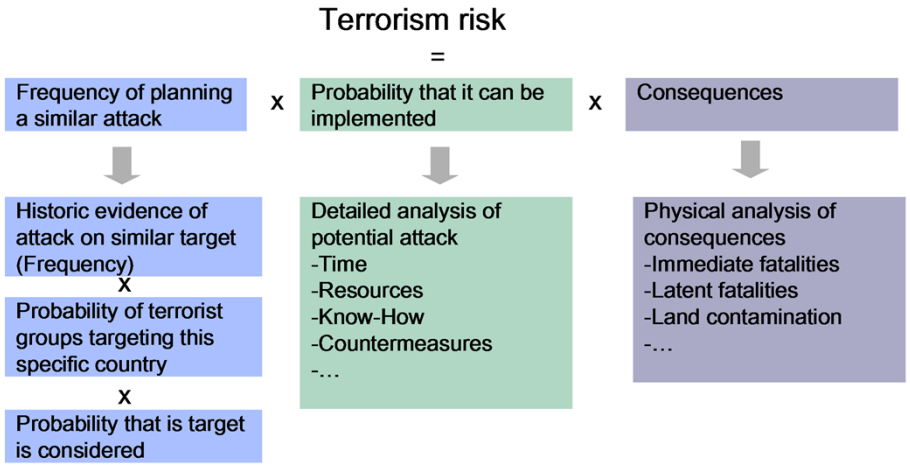
Mortality Impact of Normal Operation



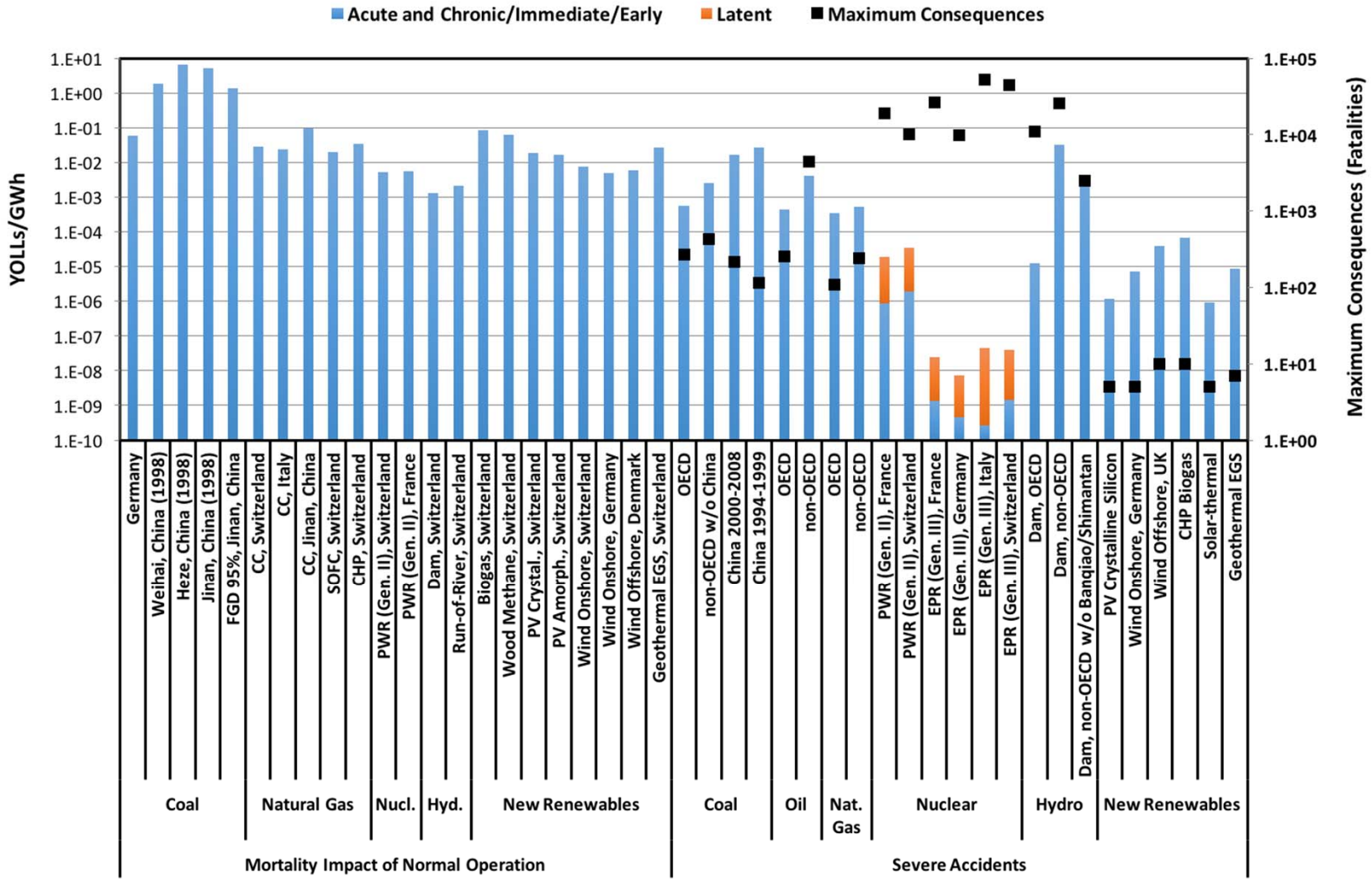
Severe Accidents



Terrorist Threat



Example: Comparison between Mortality Impact of Normal Operation and Severe Accidents

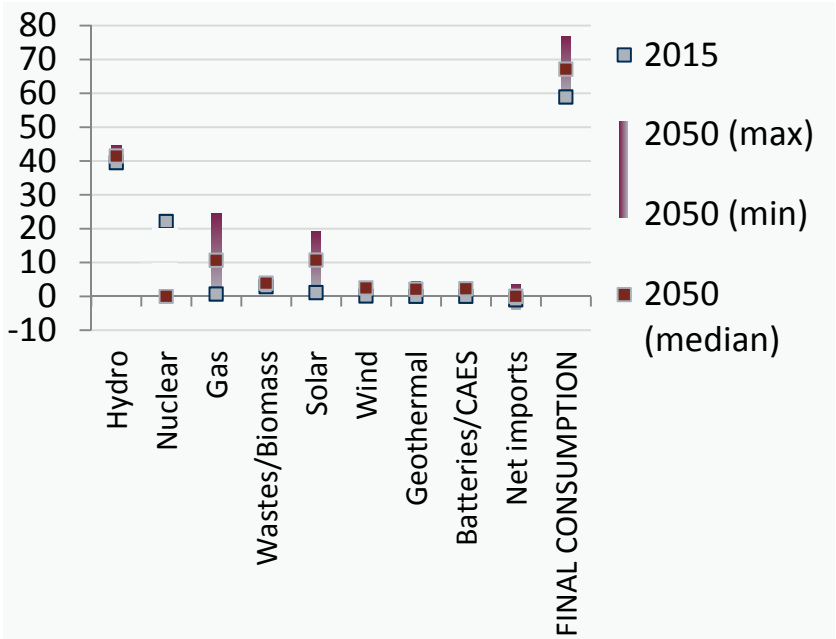


Cost-optimal future configurations: 100 scenarios assessed

Diverse assumptions on demand, policy, …

- Under climate policy, **VRES in 2050 supply 28% electricity** (ca. current % nuclear)

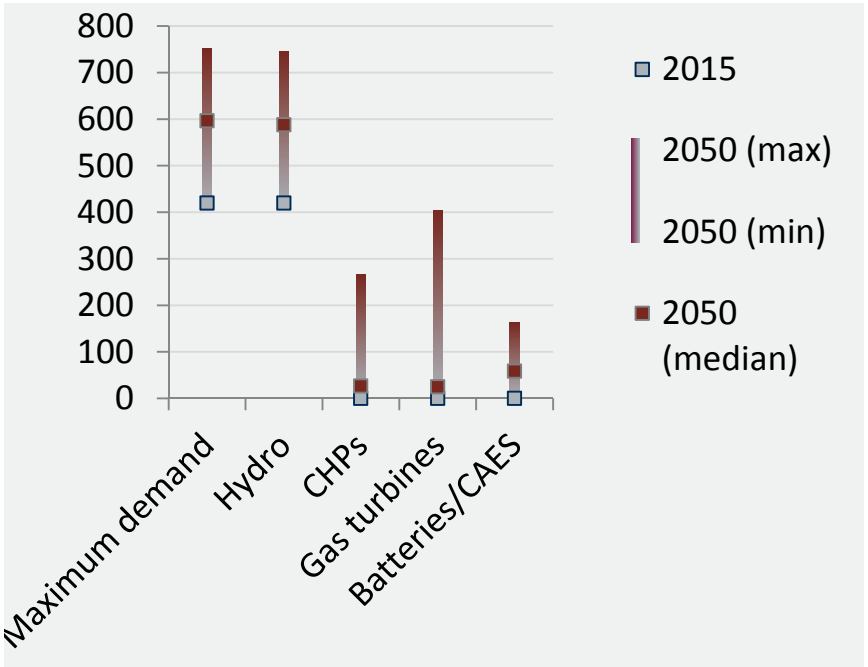
ELECTRICITY GENERATION IN 2050 (TWh)



Ranges obtained from 100 assessed scenarios

- **+50%** (median increase) vs. today
- Reserve demand : winter peak -> summer
- Hydro still main contributor to reserve

REQUIRED SECONDARY RESERVE IN 2050 (MW)



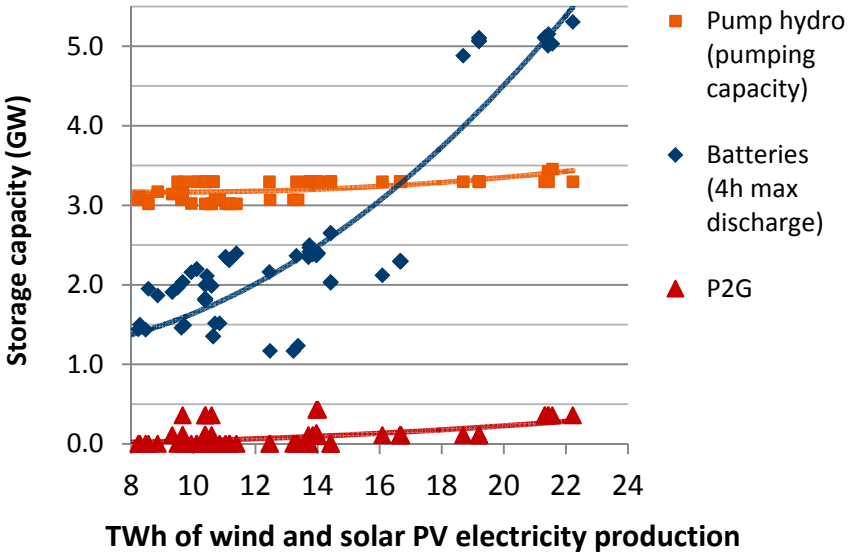
Maximum contribution per technology

- Storage technologies : LEA Technology Assessment
- Grid impacts : ETH-FEN
- Scenario analysis : LEA Energy Economics
  - Calculated with STEM (Swiss TIMES Energy Systems Model)

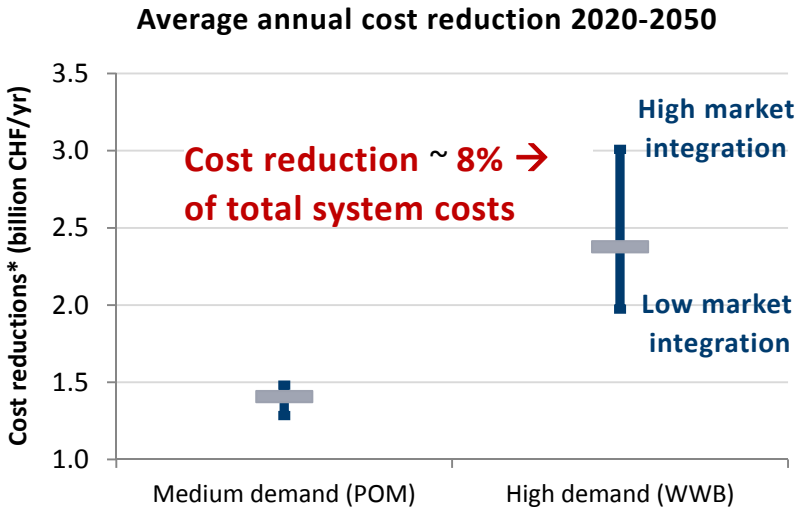
Storage and grid expansion

What is the role of flexible loads, storage, and grid expansion in integrating variable renewables in the Swiss electricity system?

- **Accommodating high shares of wind and solar PV** requires total **electrical storage peak capacity of ca. 30-50%** of installed capacity from wind and solar



- **Grid expansion helps to achieve wind and solar deployment at reduced cost**
  - ~ 8% of the system cost (electric & heat), by avoided network congestion
  - Or ~ 25% of the additional system costs to achieve the climate policy goal



- Climate policy scenarios aiming to reduce CO2 emissions by 70% in 2050 (vs. 2010)

Source: *Panos E., Kannan R., 2017, ISCHESS final project report - WP8 – Assessment of different future energy scenarios*

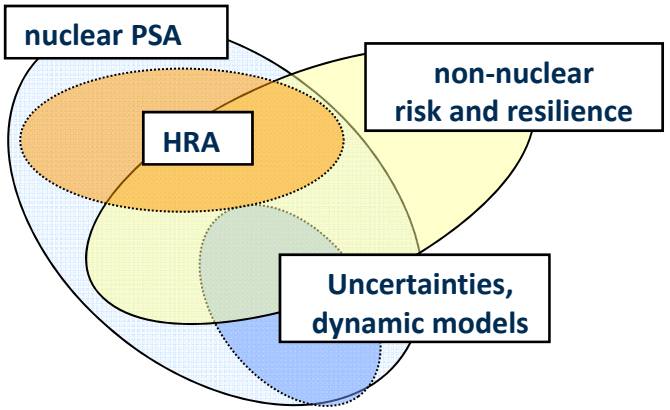
LEA Risk and Human Reliability – projects

ROES – Reliability of Operators in Emergency Situations (ENSI)

Decision errors (EOCs), HRA data collection and its quantitative application

Nuclear regulatory support (ENSI)

Review of licensee HRAs, sequence modeling, procedures



EXAR extreme flood hazard
(BAFU & federal offices)

Synthesis and probabilistic hazard estimation (WSL/PSI)

Radiotherapy HRA (PSI Center for Proton Therapy, CROSS)

HRA for human-centered processes, emphasis on healthcare

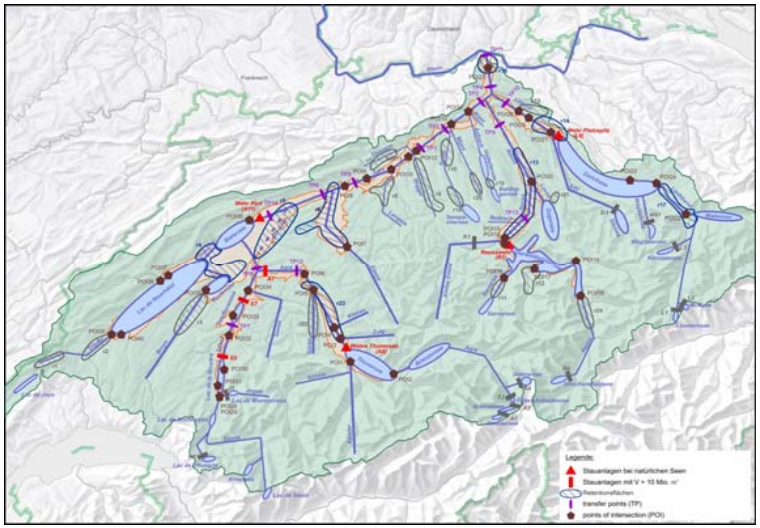
FRS - Human performance & sector resilience (NSF, Singapore-ETH Centre)

Role of Human Reliability in critical infrastructure (services)

Extreme Flood Hazard – Project EXAR

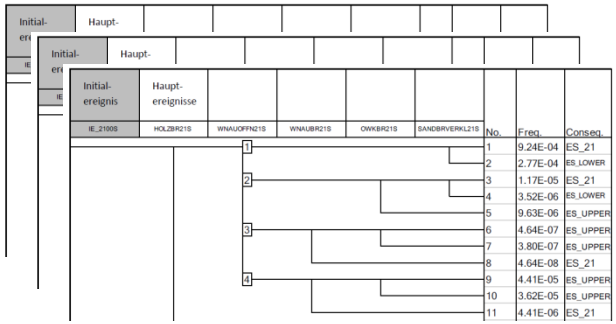
«Gefahrengrundlagen für Extremhochwasser an Aare und Rhein (EXAR)»

- **Enhanced flood hazard methodology – Phase 1**
  - flood parameters at assessment site vs. frequency
  - natural processes and hydro-eng. structures
- **Application in Phase 2 (2017-2018)**



AP2 Weather (Meteo.) & Hydrology	AP3 Hydraulics	AP4 Hydro-structures & processes	AP1 Synthesis & Scenarios

Event tree analysis - combining probabilities of scenario elements

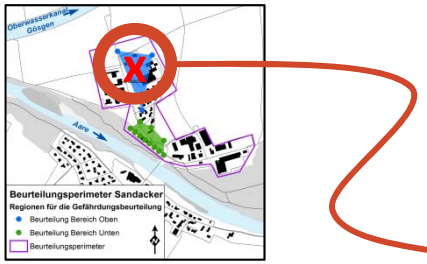


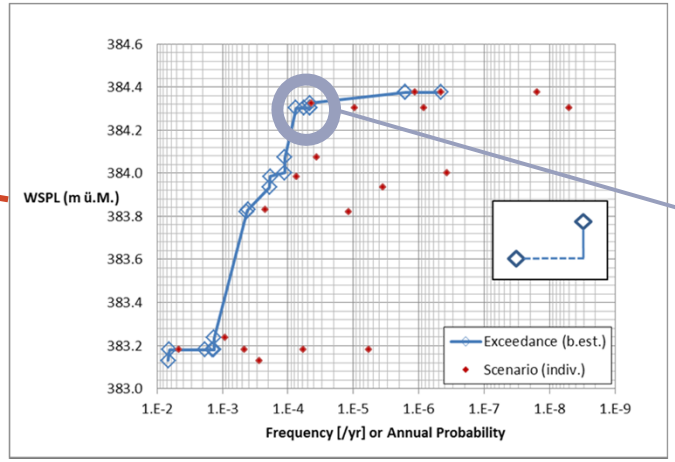
Initiating events: discharges at beginning of river reach

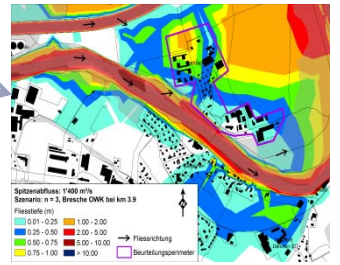
Branch: Scenario elements .. outcomes of

- phenomena and processes,
- response of structures, technical and human failures

End states: hazard parameters



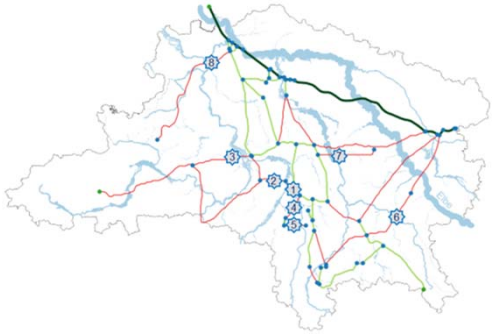


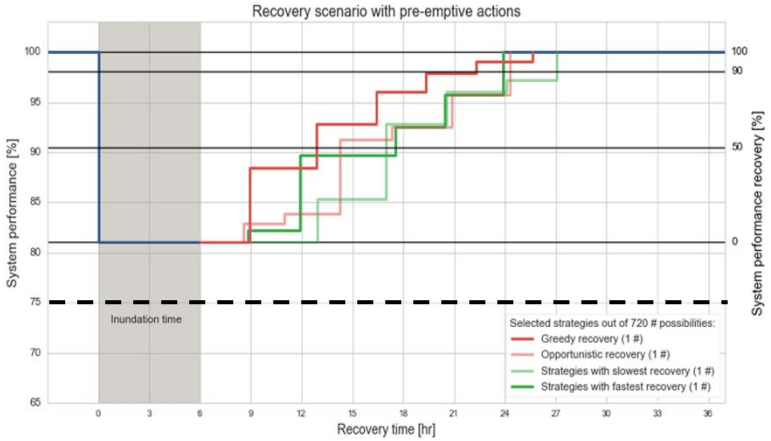


Recovery strategies for essential infrastructure services – resilience of energy supply networks

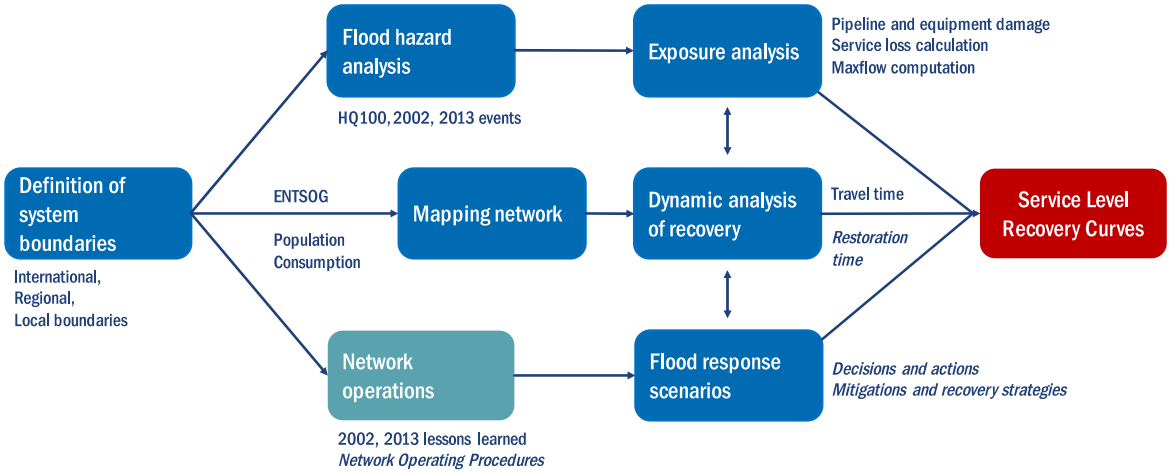
Future Resilient Systems

Singapore NRF





- How effective are response, mitigation and recovery strategies ?
- Where are the critical human and technical elements?
- How can these be supported and strengthened ?



Source: Kyriakidis, Lustenberger, Burgherr, Dang, 2017

Outlook

- Electricity, **Mobility**, **Storage**, & Joint Activities 2nd Phase SCCERs (CTI)
- Energy Systems **Integration** (ESI) Platform – systemic aspects
- **CCS** and **Hydrogen** (SFOE, ERA-NET)
- Electricity **market** designs, CH in European market (SFOE, VSE)
- Decarbonization in a **multi-regional** framework (WEC)
- **Digitalization**, grid, and flexibility

- Future **Resilient** Systems (Singapore NRF)
- Tools, methodologies, and databases – Life Cycle, Energy System models, Probabilistic Safety Assessment, etc.

- Risks and costs of **advanced nuclear** designs
- **Human performance** and reliability, regulatory support in **HRA/PSA** (ENSI)
- Extreme **flood hazards** (FOEN)

- On-going **recruitment of new LEA Head** – ETHZ Professor

PAUL SCHERRER INSTITUT

Wir schaffen Wissen – heute für morgen

Thank you for your attention!

Laboratory for Energy Systems Analysis (LEA)

http://www.psi.ch/lea

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