CATAPULT

Comprehensive AssessmenT And Preparedness for emerging nUcLear Technologies

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on behalf of the CATAPULT community

PIANOFORTE
EUROPEAN PARTNERSHIP FOR RADIATION PROTECTION RESEARCH
CATAPULT

11th NERIS Workshop, 2025, September 29th, London, UK

Co-funded by the European Union

Content

- Background
- The CATAPULT project: pillars, objectives, and methodology
- Status of the project
  - Database of source terms and siting
  - Modelling of radionuclide transport and uptake in the environment
  - Stakeholder needs for licensing application and reviews
  - Community engagement and evidence-based risk communication
- Collaboration with other projects and frameworks
- Summary

Background

- Current knowledge supporting EIA and EP&R, regulators' approaches, and risk communication mainly based on the use of large water-cooled reactors
- CATAPULT aims addressing key lacks and challenges posed by the deployment of Modular Reactors (SMRs and AMRs), e.g.:
  - **Vulnerable regions** and **specific physical/chemical characteristics** → **Lack in the state-of-art modelling** for EIA and EP&R
  - **Euratom Basic Safety Standards needs for modular reactors' deployment?**
  - **Public concerns** on new nuclear technologies → **communication and engagement** based on **principles of trust and transparency**
- **EIA not independent from the public concerns and wider risks at stake, and vice versa**
- Further isolated research in the modelling, compliance, and communication areas will not deliver on practical solutions to the existing challenges

The CATAPULT Project

- CATAPULT aims at building a comprehensive guidance for EIA and EP&R applied to Small (water-cooled) and Advanced Modular Reactors (Gas- and Lead-cooled) with tight cross-links between technical and social aspects
- Highly interdisciplinary team: 8 organizations (research centers, TSO, universities) from 8 EU countries
- PIANOFORTE Call 2, Topic 2, duration: 3 years (01.02.2025-31.01.2028)

ASNR Autorité de sûreté nucléaire et de radioprotection

KIT Karlsruhe Institute of Technology

Merience STRATEGIC THINKING

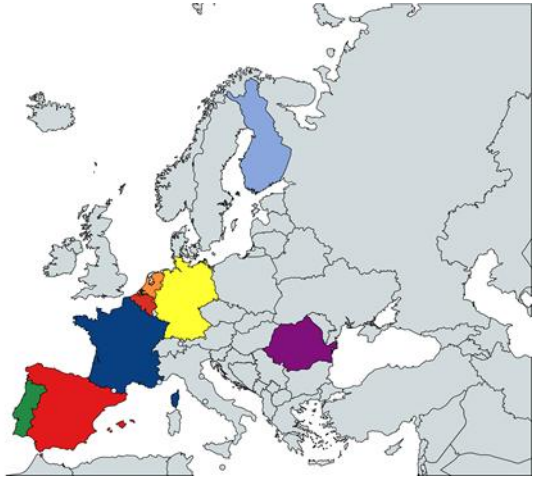
NRG PALLAS Nuclear. For Life.

RATEN ICN PITEŞTI INSTITUTUL DE CERCETĂRI NUCLEARE

sck cen Belgian Nuclear Research Centre

stuk

UNIVERSIDADE LUSÓFONA



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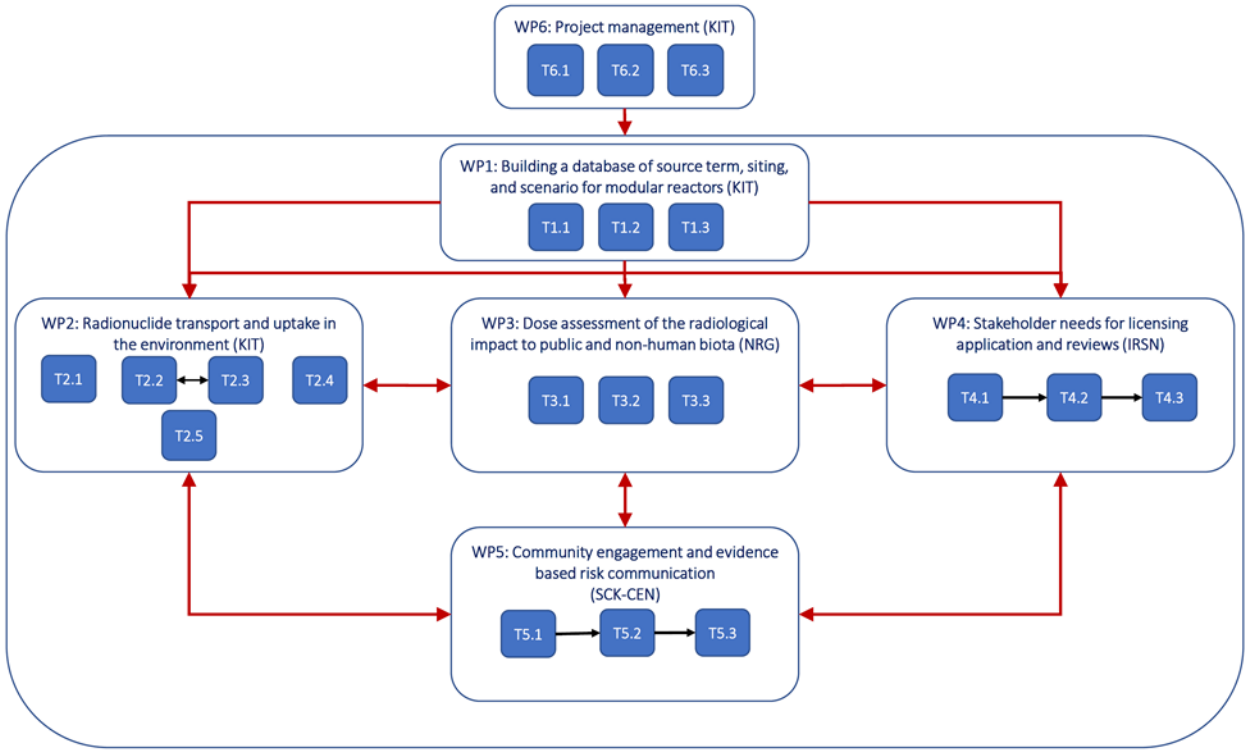
Pillars, Scope, and Main Goals

- Environmental and dose modelling
  - **Improving/adapting** the **dose** impact modelling and the environmental **transport models**
  - Delivering an **analysis framework tailored to the needs of modular reactors** and **their typical site locations** to guide end-users in the selection of computational models/methodologies needed for EIA and EP&R
- Science-based regulatory compliance
  - **Delivering a comprehensive set of recommendations** to **authorities**, **operators**, and **licensees** to ensure the scientific credibility of the demonstration of radiation protection of the public, including workers from nearby industries, and the environment
- Community Engagement & Risk communication
  - **Going beyond the existing strategies**
  - **Delivering a community-driven participatory framework**, to engage the general public, relevant stakeholders, and communities and to increase trust, transparency and co-decisions, towards a more holistic EIA
  - **Delivering guidelines to communicate EIA results** and **inform the public** about modular reactor development and implementation, through an evidence-based co-design of risk communication strategy and materials

Work Plan and Methodology

- CATAPULT combines a **broad range of disciplines related to radiation protection**
  - Reactor technology (KIT)
  - Environmental science for terrestrial and marine (KIT, SCK CEN, NRG)
  - Radiation dosimetry for humans and wildlife (NRG, SCK CEN)
  - Nuclear operation and regulatory compliance (ASNR, STUK, NRG)
  - Risk communication and public perceptions (SCK CEN, RATEN, MERIENCE, COFAC-UL)
- **Cross-fertilization of these research disciplines** to develop a fit-for purpose framework on EIA modelling, regulatory compliance, and engagement with the community



Work Plan and Methodology

- WP1 – Building a database of source term, siting, and scenario for modular reactors (**KIT**, RATEN, STUK)
  - Three generic **water-cooled iPWR**, and **Gas- and Lead-cooled modular reactors**
  - Four locations: **urbanised, industrial, and Natura 2000**
  - Postulated scenarios: emission scenarios for single and multiple reactor deployment
- WP2 – Radionuclide transport and uptake in the environment (**KIT**, ASNR, NRG, SCK-CEN, STUK)
  - **Adaptation and enhancement of state-of-the-art atmospheric and aquatic radionuclide transport and dispersion** as well as food chain models (JRODOS, SYMBIOSE, Delft3D)
- WP3 – Dose assessment of the radiological impact to public and non-human biota (**NRG**, ASNR, SCK CEN, STUK)
  - Analysis of the **present dose models for humans and wildlife based on stakeholder needs**
  - **Prioritisation of features** that are important in the assessment

Work Plan and Methodology

- Large role of Social Sciences and Humanities (SSH) Activities
- WP4 – Stakeholder needs for licensing application and reviews (**ASNR**, NRG, RATEN, STUK)
  - Development of **regulatory guidance** based on: i) **case studies,** ii) **round-tables with experts** from authorities and TSO involved in the reviewing of applications from prospective licensees, iii) **feedback from a wider audience** (developers of modular reactors and their subcontractors, public engagement and risk communication)
- WP5 – Community engagement and evidence based risk communication (**SCK CEN**, COFAC-UL, MERIENCE)
  - Develop a **two-stage Community-Driven approach** to enhance public perception and address public mistrust, mitigating "not in my backyard" (NIMBY) responses
  - Develop **citizen-centred and evidence-based risk communication strategy and materials** related to EIA by providing transparent, accurate, and comprehensible information from the other WPs (**Design Thinking Approach**)
  - The **Delphi method** will be used to provide implementation guidance for effective and evidence-based risk communication by leveraging a panel of communication experts

Database of source terms

- **No extensive integral evaluations** of ST planned in CATAPULT → focus on the project on EIA and EP&R modelling and SSH
- Three generic modular reactors considered
  - Water-cooled SMR (submerged containment, 60 Mwe)
  - Lead-cooled: ALFRED-like (125 MWe)
  - Gas-cooled: HTR-like (200 Mwe)
- The **database based on first order estimates** (nominal and accident conditions)
  - Evaluation of fuel inventories
  - Available analyses by means integral codes
  - Application of release fractions to the initial inventory (open literature, reports)

Database of source terms: status

- Lead-cooled: ALFRED-like
  - Fuel inventories at different burn-up computed by SERPENT (20, 25, 30, 50, 75 MWd/kgU)
  - ST Estimation following the failure of the heat removal system
- Water-cooled SMR
  - Fuel inventories at different burn-up computed by CASMO (up to 60 MWd/kgU)
  - ST Estimation following a station black out in conjunction of a loss of coolant scenario
- Currently..
  - Release fractions in both nominal and accident conditions identified
  - Finalization of the database

(courtesy of A. Tacu, NRG Pallas, and P. Roivainen, STUK)

Database of siting

- Typical SMR Site Characteristics
  - Preferably located 100 m from sea/coast or adjacent to suitable surface water (river, reservoir) for cooling access
  - Flat terrain with gentle slopes, outside flood zones and seismic faults
  - Not located on protected habitat, aquifer recharge zones, wetlands, or contiguous to dense population
  - Good access to infrastructure: roads, rail, transmission lines, and low-risk surrounding industrial sites

  GDA Step 2 of the Rolls-Royce SMR: fundamental assessment full report - GOV.UK

  Geographical Considerations in Site Selection for Small Modular Reactors in Saskatchewan
- Four sites
  - **Industrial site** - Stein, Limburg (Netherlands)
  - **Urbanized site** - Arnhem, Gelderland (Netherlands)
  - **Natura2000 site** - Petten (Netherlands)
  - **Urbanized site** - Helsinki (Finland)

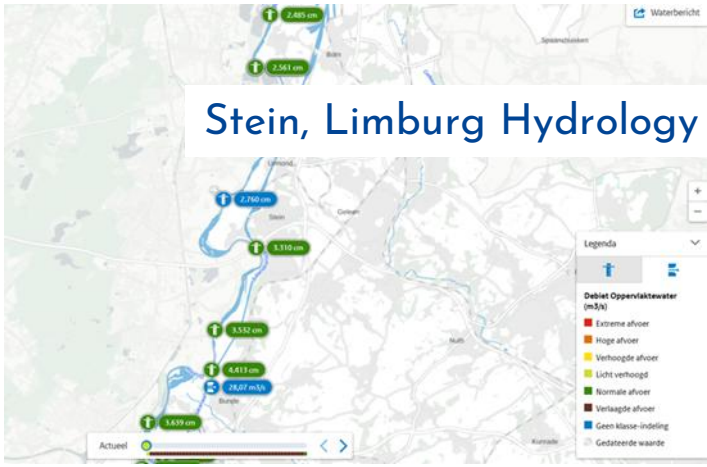
(courtesy of A. Tacu, NRG Pallas, and P. Roivainen, STUK)

Database of siting: status

- Information collected related to
  - Population
  - Buildings
  - Geology
  - Hydrology
  - Ecology, flora, fauna
  - Maps, e.g., LiDAR datasets of the City of Helsinki
  - Marin traffic

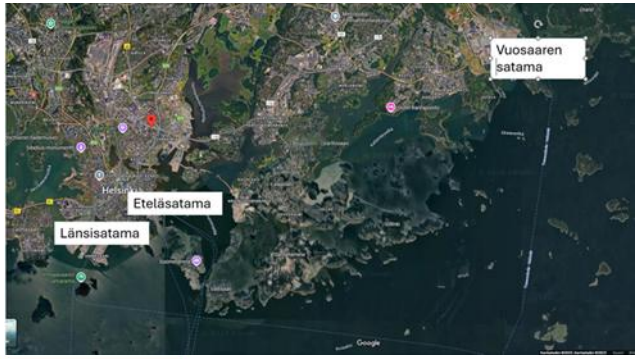
Natura2000

Stein, Limburg Hydrology



Helsinki region land cover

Marine Traffic in the Helsinki ports



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Radionuclide transport and uptake in the environment

- Reviewing and adapting models for modular reactors' applications and application to the case studies
- Atmospheric transport and dispersion models (**on-going**)
  - Improving models for small-scale and urban conditions
    - Utilize LASAIR (Lagrangian Particle Dispersion Model), developed by BfS + JRODOS
    - FLEXible PARTicle (FLEXPART) dispersion model + AROME
- Aquatic transport and dispersion models (**on-going**)
  - Customize 3D hydrological and compartment models, e.g., ERICA, POSEIDON, LAKECO, D-DAT
  - High-resolution 2D-3D hydrological modelling of radionuclide pollutants
  - Assess impact in freshwater and low-flow rivers

Radionuclide transport and uptake in the environment

- Food chain models
  - Assessment of the potential contamination of food products → focus on environments where food product contamination could be more severe
  - JRODOS for various radioecological regions (+ conceptual models and SYMBIOSE)
  - Adapt aquatic food chain models (JRODOS, SYMBIOSE, D-DAT)
  - Conduct benchmark (JRODOS/FDMT) studies for boreal environments (Finland-case)

- Radionuclides so far not considered in the current assessment models
  - Identifying radionuclides missing in the current models
  - Distinguishing corresponding physic-chemical speciation

Dose assessment of the radiological impact to public and non-human biota

- Review of models and selection of exposure conditions for members of the public including workers from nearby industries and for non-human biota
- Dose calculations and a sensitivity analysis on the variations in exposure conditions to establish variations in dose for the (critical) reference person and wildlife
  - Variations in exposure conditions and consideration on end-user needs (see next)
  - Identify deficiencies providing input for a work plan on future development
- The findings from the dose assessment will be used for the prioritisation of relevant features based on the stakeholder needs (see next) and feed into a graded approach
- The graded approach will provide recommendations to be considered in the dose assessment

Stakeholder needs for licensing application and reviews

- Providing recommendations to various actors about EIA and EP&R, regarding the aspects tackled in the project (in particular, but not only, radiological impact) in terms of data gaps and prioritisation of stakes based on
  - case studies and in particular a sensitivity study approach
  - an initial round table, 6-7 May 2025, with experts from the authorities and TSOs involved in examining the applications of future licensees
  - feedback from a wider audience, e.g., developers of modular reactors, their subcontractors and representatives of public engagement and risk communication

(courtesy of M. Simon Cornu, ASNR)

Round Table, ASNR, Paris, 6-7 May 2025

- 7 participants from 4 organizations (ASNR, RATEN, STUK, SCK CEN) and from 4 countries (RO, FI, FR, B)
- **Diversity among participants** in terms of
  - **Backgrounds and roles**
    - close to the licensing authority vs. to the licensees, RP vs Nuclear Safety, concerned by normal operation vs accicental scenarios)
  - **SMR projects status**, and « **spirit** » **of the legislation** (more or less prescriptive, is it an effort to make it more techology neutral?) and of its application by TSO/authority (more or less incentive-based)
- One example: the margin between the authorized source term for normal operation and the real discharges is seen very differently from one country to another one

Community Engagement and Evidence-Based Risk Communication in Environmental Impact Assessment for Small Modular Nuclear Reactors

EIA:

*"to inform the authorities within a process of making decisions identifying, describing and assessing prospectively the effects and the risk of effects of a proposed activity or facility on aspects of environmental and socio-economic significance and **summarising the opinion of stakeholders**."*

(IAEA, 2020, Considerations for EIA for SMRs)

(courtesy of T. Perko, SCK CEN)

Community Engagement and Evidence-Based Risk Communication in Environmental Impact Assessment for Small Modular Reactors

What approaches best support the public, stakeholders, and experts in developing informed perspectives and providing meaningful contributions to EIAs for SMNRs?

(Borsele conditions, 2023)

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(IAEA, 2020, Considerations for EIA for SMRs)

(courtesy of T. Perko, SCK CEN)

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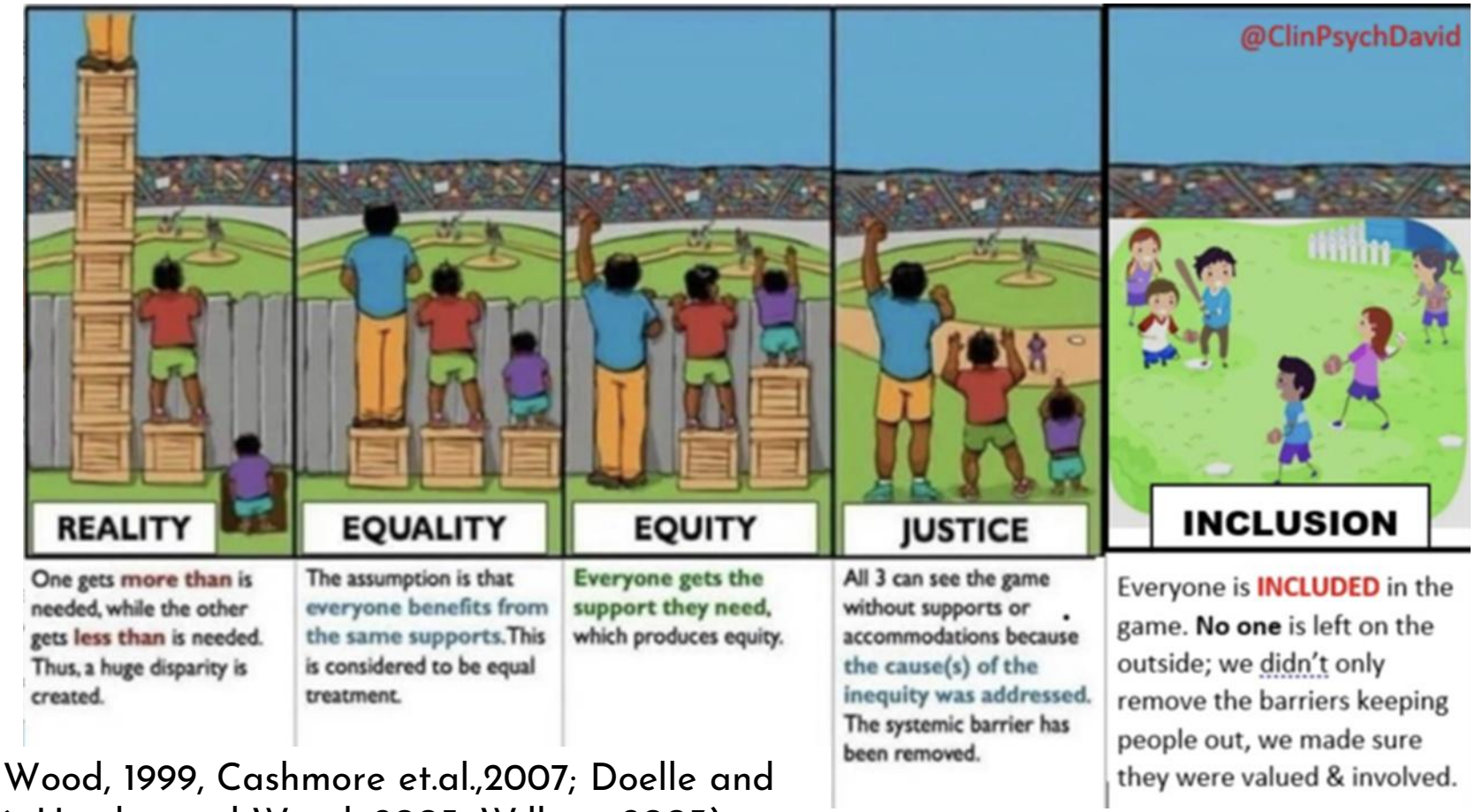
Why is forming an informed opinion in EIA challenging?

Lack of
equity, justice
and inclusion



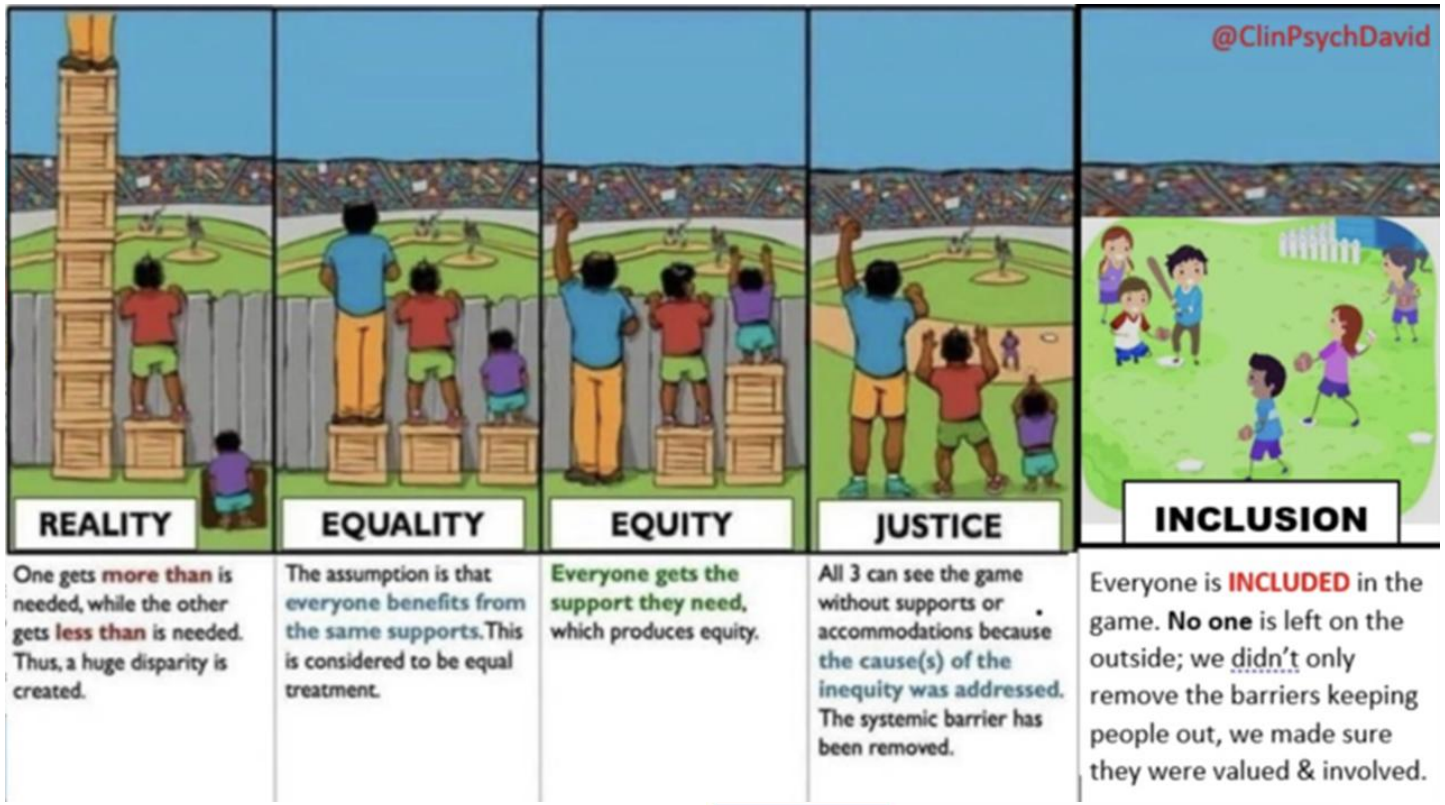
(Barker and Wood, 1999, Cashmore et.al.,2007; Doelle and Sinclair, 2026; Hartley and Wood, 2005; Wilkins, 2003)

We are:

Providing Equity, Justice, and Inclusion

1. Developing a Community-Driven Framework for EIA
2. Engaging Citizens in Co-designing Risk and EIA Engagement Strategy and Materials
3. Providing Implementation Guidance for Effective Risk Communication during EIA process

(courtesy of T. Perko, SCK CEN)



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(courtesy of T. Perko, SCK CEN)

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Objectives:

1. Develop a Community-Driven Framework for EIA

A comprehensive theoretical, practical, and methodological framework to address the knowledge and understanding of the EIA process for SMRs deployment

2. Engage Citizens in Co-designing Risk and EIA Engagement Strategy and Materials

Citizen-centered and evidence-based risk communication materials

3. Provide Implementation Guidance for Effective Risk Communication during EIA process

Develop and finetune the practical guidance with stakeholders

Method:

- PRISMA literature review
- Semi structured interviews with residents (40 from two local communities) and EIA or SMR experts (30)
- Create an "Emerging Technologies Citizens' Committee" (12-20 members)

(1st of February, 2025 to 30th of January, 2027)

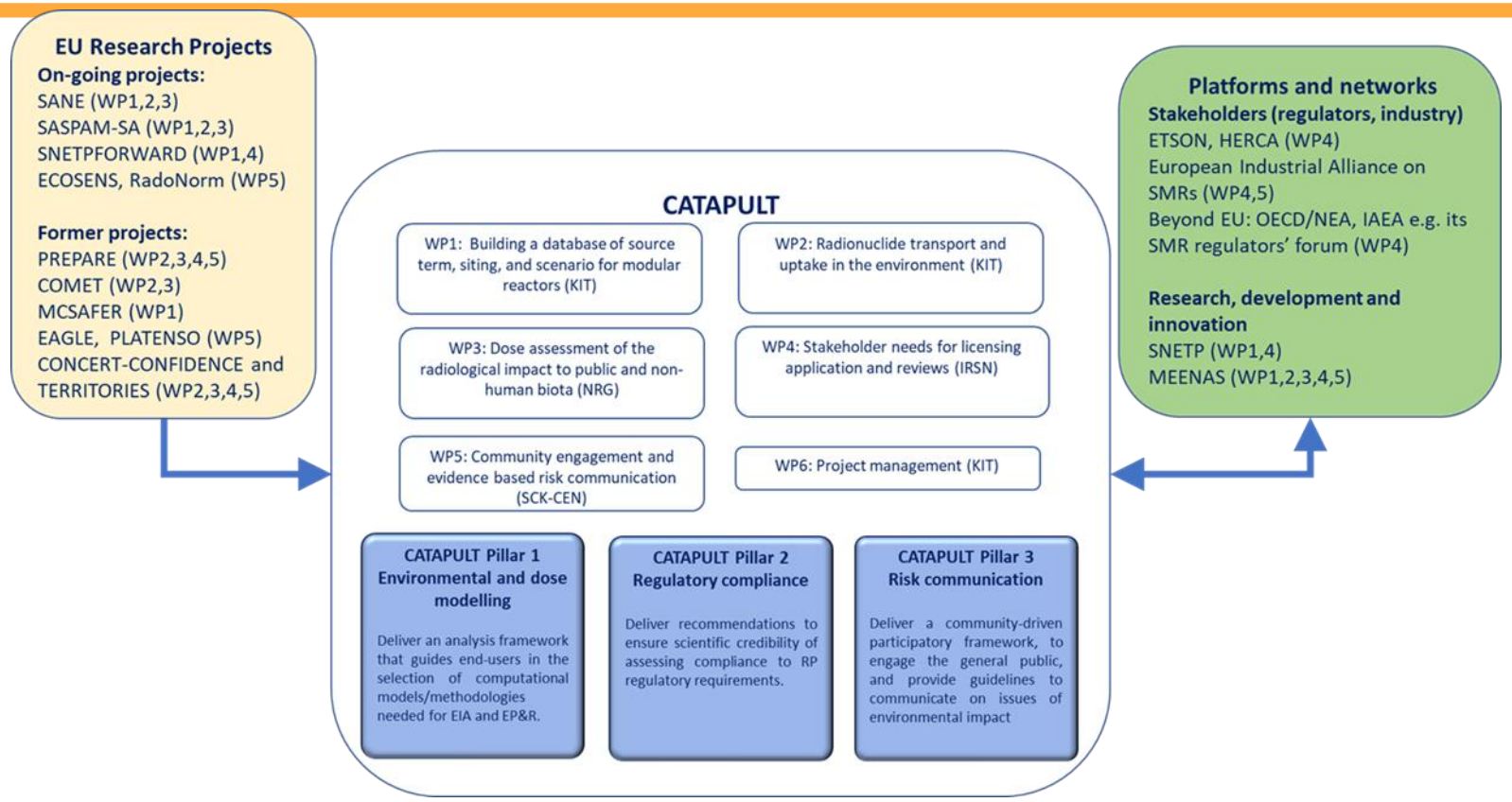
- Design thinking workshops with residents (3)

(30th of April, 2026 to 31th of August, 2027)

- Delphi method: series of structured rounds, starting with results from previous work, initial questionnaire to gather communication and other relevant experts insights, followed by rounds of feedback and refinement

(27th of February, 2027 to 30th of November, 2027

CATAPULT in the EU Projects' and Platforms' Context



- E.g., the activities on 'Community engagement and evidence based risk communication' will build on the framework analysed and data collected in the ENGAGE and ECOSENS projects

Sinergies with the GIROSCOPE Project

- CATAPULT tightly connected with the GIROSCOPE project (see next presentation from A. Wawrzyńczak-Szaban, NCBJ)
- **Several sinergies already identified through common meetings**
  - Modelling approaches for environmental transport of radionuclides, similar approaches and sometimes same codes employed, e.g., JRODOS
  - Recommendations for EP&R and safety cases – checking for the consistency of the outcomes
  - Stakeholders feedback and Public perception – PIANOFORTE WP3
- Common projects' review meetings as well as on specific topics/taks planned
- CATAPULT/GIROSCOPE presentation at the plenary session on EPRR for SMRs/AMRs of the European Radiation Protection Week

Summary

- **CATAPULT** is tailored at the specific needs of **modular reactors** (nuclear technology and site location) in assessing their **radiological risks** to the environment during routine and accidental operation

- The framework is **evidence based**, **builds on state-of-the-art science in environmental and dose modelling**, contributes to **new communication science**, and is driven by an **extensive stakeholder and community engagement programme**

- Through a **multi-disciplinary team**, CATAPULT has the **potential to deliver on a valuable outcome** that provides essential **guidance to all stakeholders** (e.g. authorities, TSOs, operators, licensees) involved in the licensing of modular reactors, and **develops a first step towards a standardised and fit-for-purpose approach in EIA and EP&R**

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Follow us

- J. Reese, R. Gaspar, S. Domingos, A. R. Farias, S. Luis, M. Martell, T. Perko, "Stakeholder and Public Engagement in Environmental Impact Assessments: Considerations and Lessons for the Implementation of Small Modular Reactors", "Final ECOSENS Conference "Futures for nuclear energy? Social, economic and environmental considerations", September 8th-9th, 2025, POLIMI, Milano, Italy
- R. Gaspar, T. Perko, M. Martell, J. Reese, S. Luis, S. Domingos, A. R. Farias, "Community Engagement and Evidence-Based Risk Communication in Environmental Impact Assessment for Small Modular Reactors", "Final ECOSENS Conference "Futures for nuclear energy? Social, economic and environmental considerations", September 8th-9th, 2025, POLIMI, Milano, Italy

- https://pianoforte-partnership.eu/catapult/
- https://www.linkedin.com/company/pianoforte-partnership/
- https://www.youtube.com/@PianofortePartnership

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The CATAPULT Community

- M. Simon-Cornu, M. Roulier, N. Didelot, G. Mathieu, A. Mathieu (ASNR)
- R. Gaspar, S. Luís, S. Domingos, A. R. Farias, J. Reese (COFAC-UL)
- F. Gabrielli, M. E. Cazado, O. Murat, S. S. Ottenburger, D. Trybushnyi, W. Raskob (KIT)
- M. Martell Lamolla (Merience SCP)
- G. De With, B. Mayer, A. Tacu, T. Van Dijk (NRG Pallas)
- D. Diaconu, M. Nitoi, M. Constantin, C. Dulama, M. Apostol (RATEN)
- T. Perko, J. Camps, J. Vives i Battle, T. Al Malhaini, A. Nagy, P. De Meutter (SCK CEN)
- P. Roivainen, T. Routamo, T. Peltonen, M. Voutilainen, E. Hiittenkivi, J. Mannonen (STUK)

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