Rethinking Emergency Preparedness for Small and Advanced Modular Reactors: the PIANOFORTE GIROSCOPE and CATAPULT projects

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ERPW
EuropeanRadiationProtectionWeek
London 2025
29th September – 3rd October

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OUTLINE

- Challenges of EIA and EP&R for SMRs
- SMRs status and development in Europe
- The PIANOFORTE answer to the challenges:
  call 2 the CATAPULT and GIROSCOPE projects
  - Pillars, Scope, and Main Goals
  - Milestones achieved
  - Preliminary results
- Conclusions

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Backgroung

- Current knowledge supporting Environmental Impact Assessment (EIA), Emergency Preparedness and Response (EP&R), regulators' approaches, and risk communication mainly based on the use of **large water-cooled reactors**

- Several challenges posed by the deployment of small and advanced modular reactors, e.g.
  - unaccustomed source terms, specific design characteristics
  - small EPZ and vulnerable siting
  - new Euratom Basic Safety Standard needs?
  - Lack in public/community-driven participatory practices often associated with low trust, transparency and engagement in EIA decision-making
  - Lack of practical guidelines for evidence-based risk communication and public, community & stakeholder involvement in EIA process for deployment of advanced nuclear technologies

- Further isolated research in modelling, compliance, and communication areas will not allow answering the challenges → **need of a comprehensive approach tightly cross-linking technical and social aspects**

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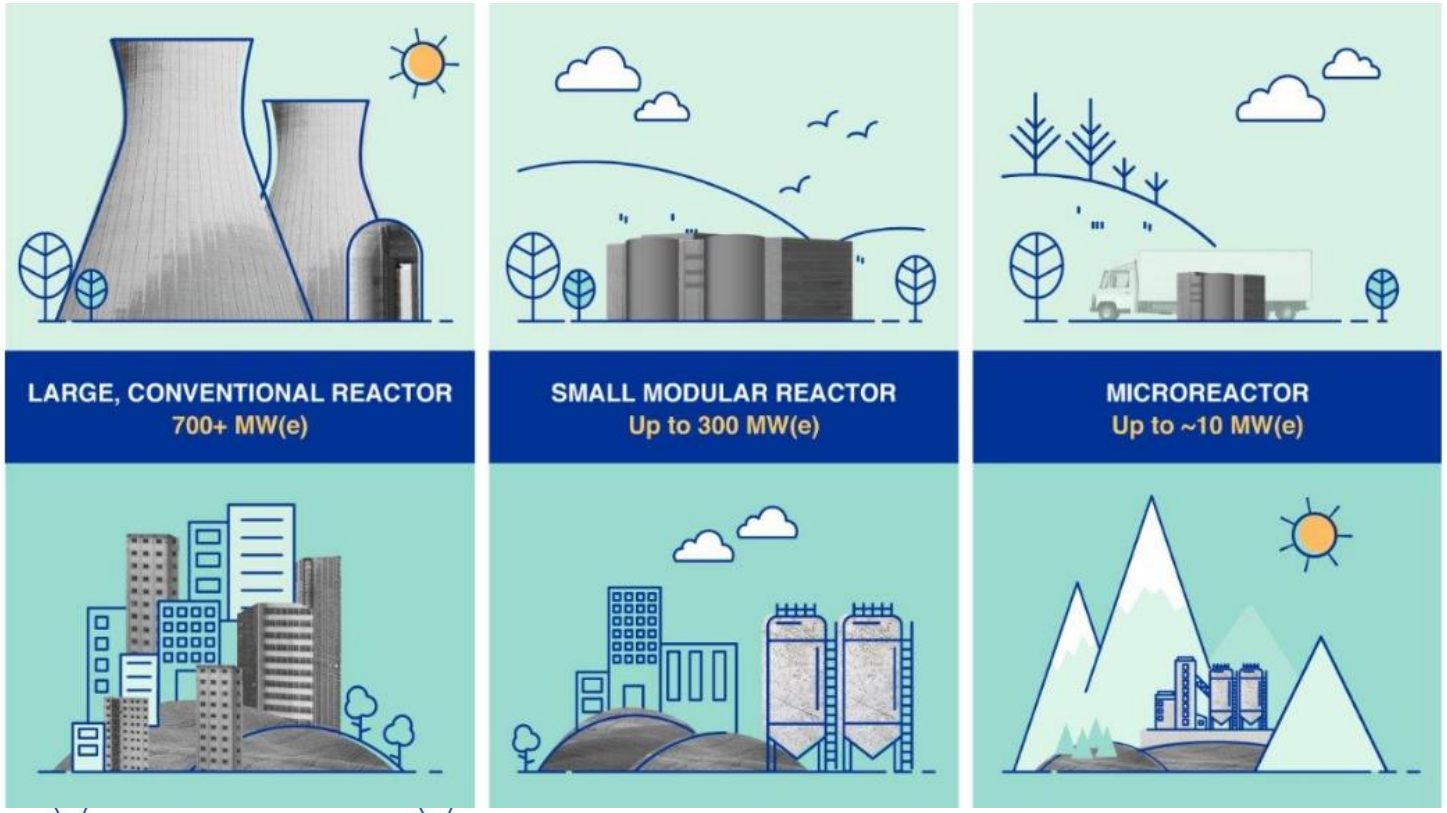
Small Modular Reactors

- Advanced Reactors that produce typically up to 300 MW(e), built in factories and transported as Modules to sites for installation as demand arises.



Small: in size, compared to traditional reactors.

Modular: factory-manufactured, installed onsite.

Reactor: energy generation via nuclear fission.

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Technology Categorization

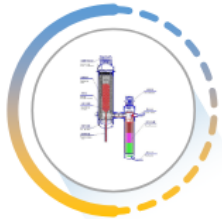
Water Cooled (Land based)
PWRs, BWRs and HWR type SMRs

Marine-based Reactors
Mainly PWRs; Some are non-water-cooled reactors with capacity less than 100 MWe

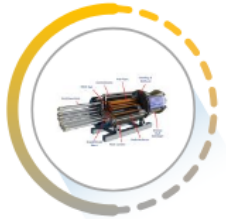
Molten Salt Reactors
Can operate at high temperature under atmospheric pressure

SMR Technology Lines

Liquid Metal Cooled Fast Reactors
Better utilization of uranium resources with lower radioactive waste



High Temperature Gas Cooled Reactors
Suitable for cogeneration purposes due to high exit temperatures



Microreactors
A subset of small modular reactors with the power up to 10 MWe

Microreactors are intended for another niche market such as off-grid remote regions, small islands, and as power source for mining industries

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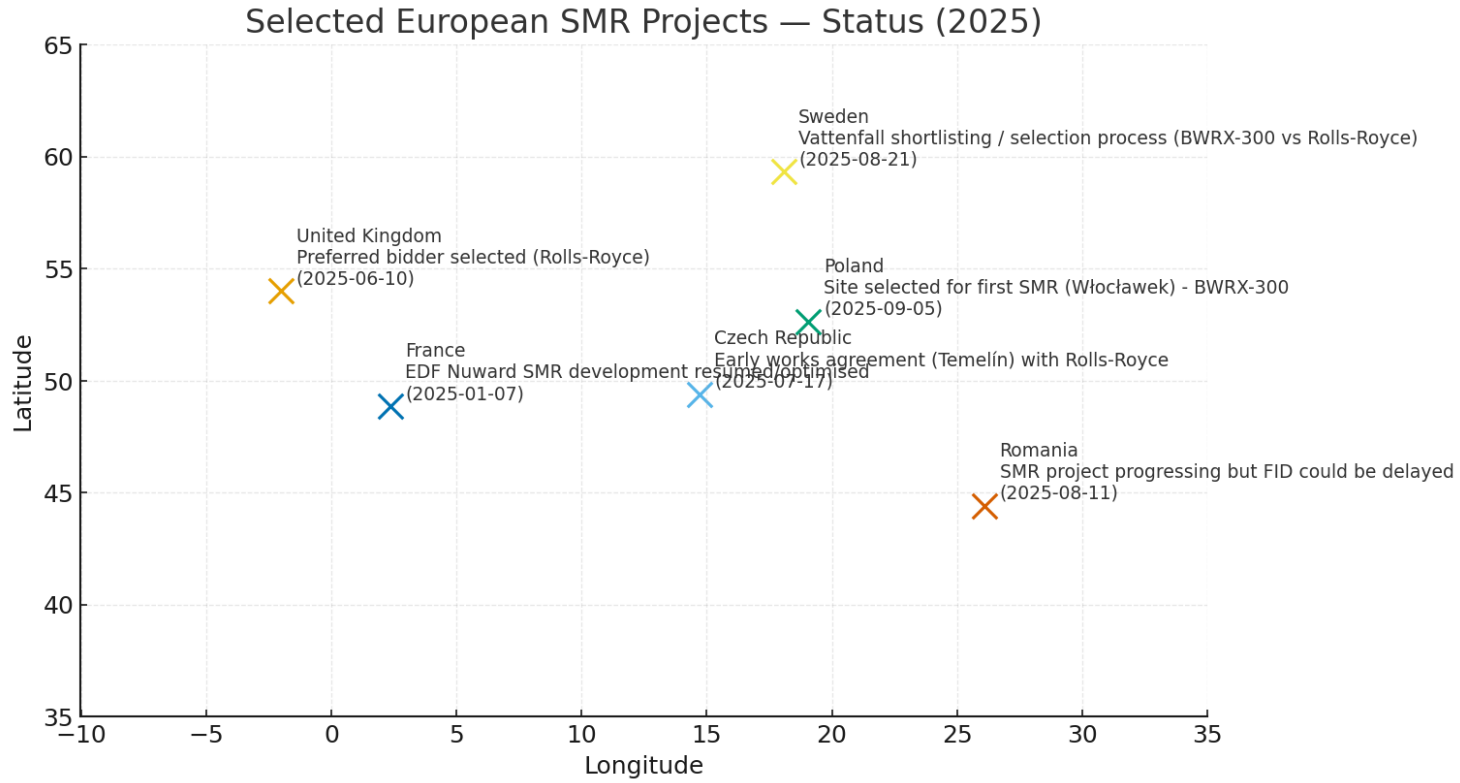
Map – Selected European SMR Projects



Notes: markers show countries with notable SMR activity or agreements in 2025. Status captions are brief summaries.

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The GIROSCOPE and The CATAPULT Projects

- The PIANOFORTE GIROSCOPE and the CATAPULT projects, started in 2025, aim at
  - investigating and addressing the knowledge gaps, capability, and advice
  - building a comprehensive guidance with **tight cross-links between technical and social aspects**
  - …. related to EIA and EP&R for small and advanced modular reactors

- Several advanced modular generic concepts in the focus
  - Small light water reactor (GIROSCOPE, CATAPULT - submerged containment, 60 Mwe)
  - Gas cooled reactor: HTGR-POLA (GIROSCOPE), generic HTR (200 MWe, CATAPULT)
  - Lead cooled reactor: ALFRED-like (125 MWe, CATAPULT)
  - Compact Molten Salt Reactor (GIROSCOPE)

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The CATAPULT Team

Karlsruhe Institute of Technology, KIT, Germany	**Radiation and Nuclear Safety Authority of Finland, STUK, Finland**	**University of Eastern Finland, UEF, Finland**	**Helmholtz-Zentrum Dresden-Rossendorf, HZDR, Germany**	**Nuclear Safety and Radiation Protection Authority, ASNR, France**	**National Institute for Public Health and the Environment, RIVM, Netherlands**
Germany	Finland	Finland	Germany	France	Netherlands
Nuclear Research and consultancy Group, NRG, Netherlands	**Belgian Nuclear Research Centre, SCK CEN, Belgium**	**Technologies for Nuclear Energy State Owned Company, Raten, Romania**	**Institute of Atomic Physics, IFA, Romania**	**Merience SCP, Spain**	**Research Centre for Energy, Environment and Technology, CIEMAT, Spain**
Netherlands	Belgium	Romania	Romania	Spain	Spain

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The GIROSCOPE Team

National Centre for Nuclear Research, NCBJ, Poland	**Research Centre for Energy, Environment and Technology, CIEMAT, Spain**	**Norwegian University of Life Sciences, NMBU, Norway**	**Federal Office for Radiation Protection, BfS, Germany**	**University of Gothenburg, Sweden**	**Nuclear Protection Evaluation Center, CEPN, France**
Poland	Spain	Norway	Germany	Sweden	France
Nuclear Safety and Radiation Protection Authority, ASNR, France	**Canadian Nuclear Laboratories (CNL), Canada**	**Portuguese Environment Agency, APA, Portugal**	**UK Health Security Agency, UKHSA, United Kingdom**	**National Centre For Scientific Research Demokritos, NCSRD, Greece**	**NERIS platform**
France	Canada	Portugal	United Kingdom	Greece	

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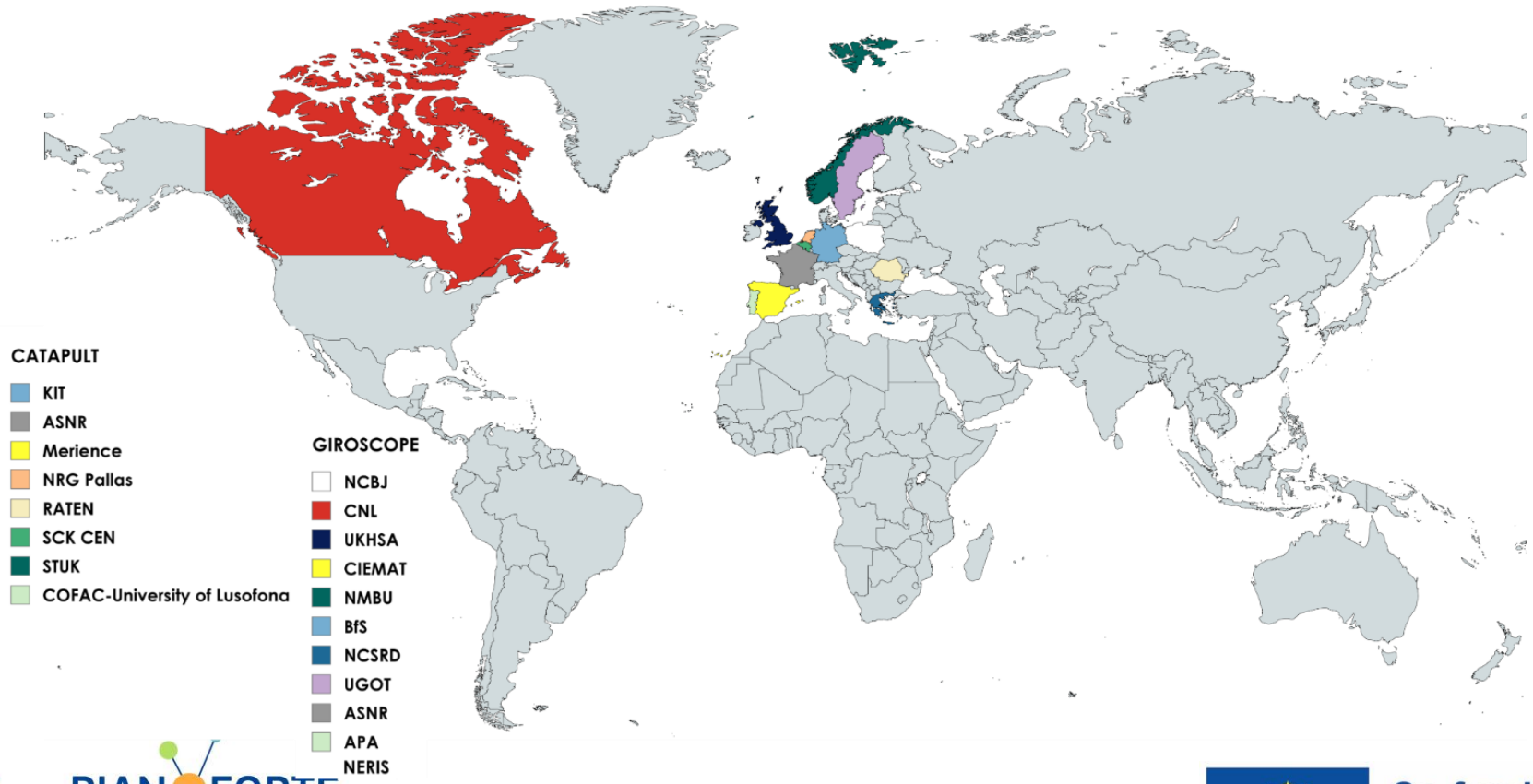
The GIROSCOPE and The CATAPULT Consortia

- Highly interdisciplinary research teams with broad expertise in EIA and EP&R (research centers, TSO, universities)



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Pillars, Scope, and Main Goals

- Synergic allocation of the resources to face the challenges posed by small modular reactors
  - CATAPULT put more effort into the SSH and transport, and dispersion models
  - GIROSCOPE analyses reactor design characteristics with ST evaluation and transport and dispersion models
- Database of source term and siting for advanced modular reactors
- Environmental and dose modelling
  - **Improving/adapting** the **dose** impact modelling and the environmental (atmospheric, aquatic, food chain) **transport and dispersion models**
- Science-based regulatory compliance
  - **Delivering recommendations** to **authorities**, **operators**, and **licensees** about EIA and EP&R in terms of data gaps and prioritisation of stakes through stakeholder engagement
- Community Engagement & Risk communication
  - **Engaging Citizens in Co-designing Risk and EIA Engagement Strategy and Materials**
  - **Developing a community-driven framework** for EIA

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Database of Source Terms (nominal and accident conditions)

- **CATAPULT**
  - **No extensive integral evaluations** of ST planned → focus on the project on EIA and EP&R modelling and SSH
  - **Database mainly based on first order estimates**

- **GIROSCOPE**
  - **Develop a methodology for ST characteristics for advanced modular reactors** taking into account
  - **… the unique features** (operating conditions, design characteristics)
  - **… new potential release pathways**

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Database of Siting

- **CATAPULT -** wide characterisation (population, buildings, geology, hydrology, …)
  - **Industrial site** - Stein, Limburg (Netherlands)
  - **Urbanised site** - Arnhem, Gelderland (Netherlands)
  - **Natura2000 site** - Petten (Netherlands)
  - **Urbanized site** - Helsinki (Finland)
- **GIROSCOPE**
  - **Industrial site:** Mobile/Maritime, seaports Ships (Norway);
    Värö Peninsula at Ringhals Nuclear Power Plant, (West Sweden)
  - **Urbanised site:** Aghia Paraskevi, Athens (Greece),
    Otwock-Świerk, (Poland ->HTGR-Pola)
  - **Natura2000 site** : Torrevieja Alicante province (Spain) ,
    Aure and Heim, (Norway)

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Environmental and Dose Modelling

- Reviewing and **improving/adapting** the environmental **transport and dispersion models (atmospheric and aquatic) as well as food chain models** for advanced modular reactors' applications and application to the case studies
- Large spectrum of codes/methods considered, e.g.,
  - **CATAPULT**: LASAIR, JRODOS, FLEXPART-AROME, ERICA, POSEIDON, LAKECO, D-DAT, SYMBIOSE, CFD,
  - **GIROSCOPE**: LASAIR, JRODOS, DIPCOT, ADREA-HF, SLAM, pX, ARTM-DARTM, LASAIR, QUIC, PEACE, PC-CREAM
- Identification of the gaps in the capabilities of the existing dispersion models when applied to the characteristics of the sites
  - small spatial scales and high spatial resolution
  - complex terrain, urban and industrial areas
  - freshwater and low-flow rivers
  - radionuclides missing in the current models
- Benchmarking new and existing models
- Develop a framework and novel approaches for atmospheric transport modelling in EP&R and routine EIA

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Environmental and Dose Modelling

- 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
  - 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 and feed into a graded approach
- The graded approach will provide recommendations to be considered in the dose assessment

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Stakeholder Engagement: Needs for Licensing Application and Reviews

- Assessing a regulatory guidance for EIA and EP&R for advance modular reactors

1. Drafting recommendations in terms of data gaps and prioritisation of stakes
    - Engagement of stakeholders (authorities and TSO) involved in licensees to support the review/improvement/development of dispersion and dose models
        - round tables
2. Validation of the recommendations
    - extending the engagement to modular reactors' developers, sub-contractors, communities
        - workshops
3. Delivering the recommendations to communities, nuclear industry stakeholders, policymakers

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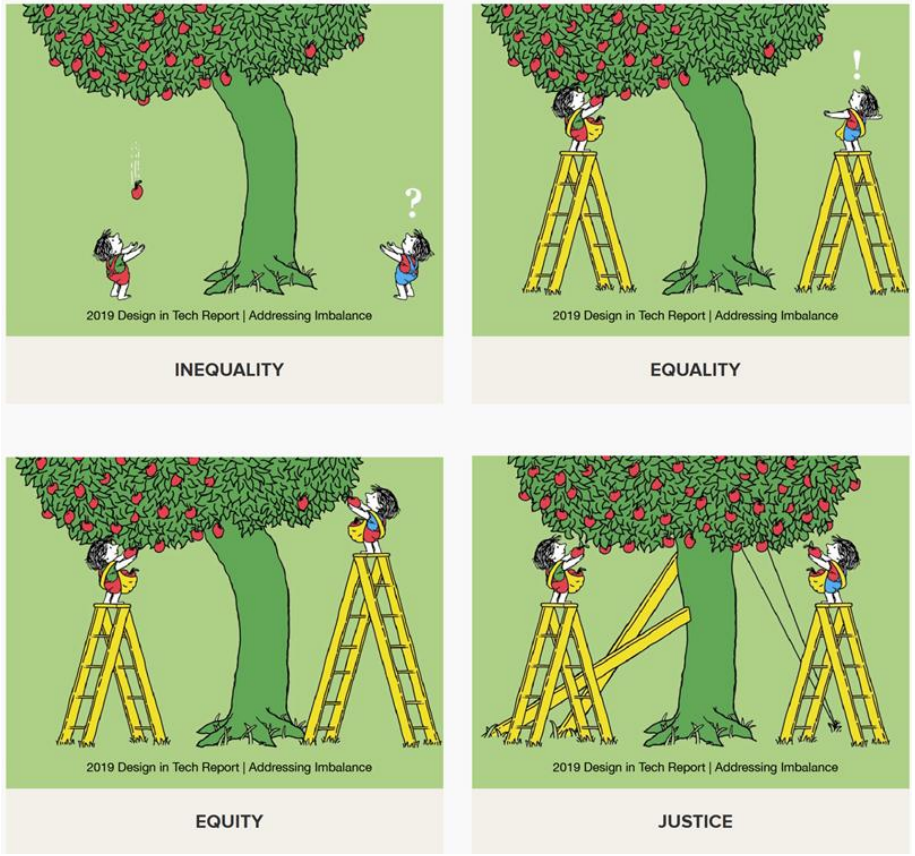
Community Engagement and Evidence-Based Risk Communication

(courtesy of T. Perko, SCK CEN, and R. Gaspar, COFAC-UL)

- … driven by principles of trustability and transparency
- **Delivering a community-driven participatory framework for EIA**
  - Develop a comprehensive theoretical, practical, and methodological framework to address the knowledge and understanding of the EIA process
- **Engage Citizens in Co-designing Risk and EIA Engagement Strategy and Materials**
  - Citizen-centered and evidence-based risk communication materials
- **Provide an Implementation Guidance for Effective Risk Communication during EIA process**



https://onlinepublichealth.gwu.edu/resources/equity-vs-equality/

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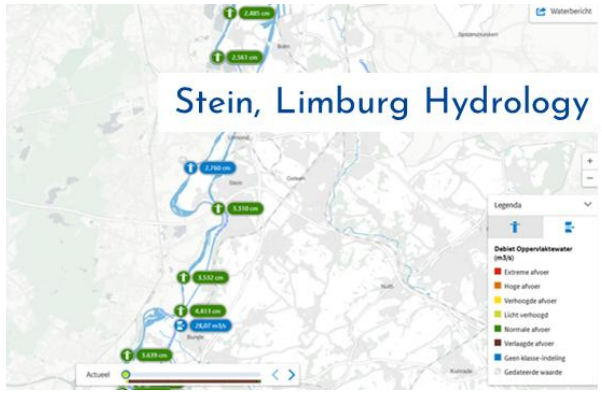
CATAPULT: Milestones Achieved and Preliminary Results

- **Database of source terms and of the siting**
  - Evaluation of the source terms - **soon available**
  - Characteristics of the siting - **completed**
    - population, buildings, geology, hydrology, ecology, maps, maps, …

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



- **Atmospheric and aquatic transport and dispersion models**
  - Review and identification of gaps/needs - **on going**

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CATAPULT: Milestones Achieved and Preliminary Results

- **Stakeholder needs for licensing application and reviews** (courtesy of M. Simon Cornu, ASNR)
  - Round Table organized by ASNR (6-7 May 2025, Paris)
  - 7 participants from 4 organizations (ASNR, RATEN, STUK, SCK CEN) and from 4 countries (RO, FI, FR, B)
  - Participants with different background and roles, e.g., licensing authority, nuclear reactor safety experts, different status of SMR-related projects, legislation

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CATAPULT: Milestones Achieved and Preliminary Results

Community Engagement and Evidence-Based Risk Communication

(courtesy of T. Perko, SCK CEN)

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

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", ECOSENS, September 8-9, 2025, 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", ECOSENS, September 8-9, 2025, Milano, Italy

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GIROSCOPE: : Milestones Achieved and Preliminary Results

- **Database of source terms**
  - accident scenarios for SLWR and HTGR (Canada, CNL).
  - source term for annual releases and fluctuations from SLWR in Sweden.
  - ongoing modelling in Poland and in Sweden for accident scenarios for HTGR-POLA and SLWR Rolls-Royce preferred in Sweden
  - under development the source term for CMSR accident and normal operation

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GIROSCOPE: : Milestones Achieved and Preliminary Results

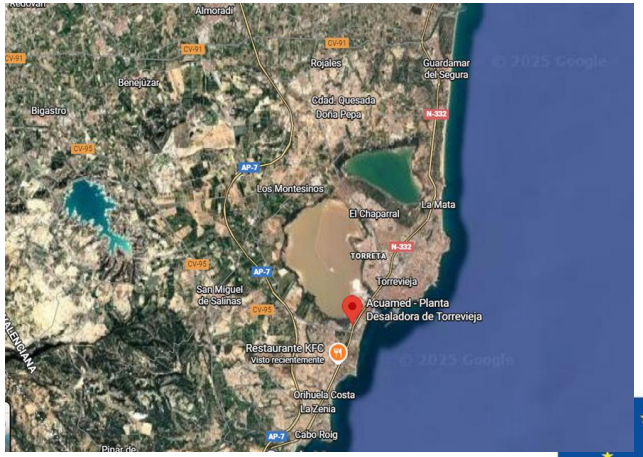
- **Database of the siting**

Świerk Nuclear Research Center – HTGR-Pola, Poland

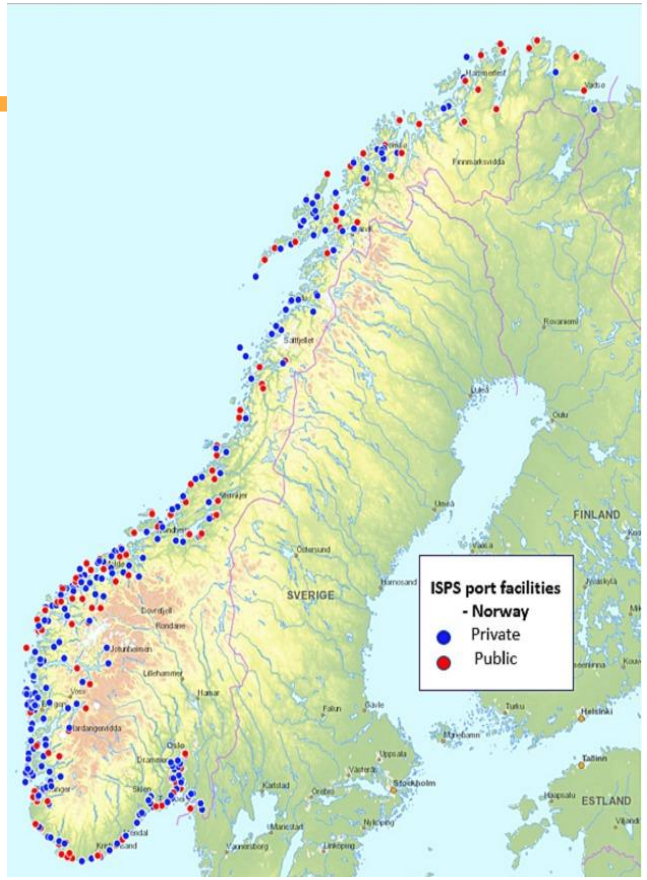
Aghia Paraskevi, National Center for Scientific Research "DEMOKRITOS",

Värö Peninsula, Sweden – Ringhals NPP Location

Map of Aure and Heim Locations in Norway



Torrevieja area with the location of the hypothetical NNR , Spain



Potential maritime routes for a nuclear-powered vessel in Norway

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GIROSCOPE: : Milestones Achieved and Preliminary Results

Mapping Societal Aspects of Novel Nuclear Reactor Technologies

- Literature review ongoing

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Summary

- The PIANOFORTE CATAPULT and GIROSCOPE projects aim at facing the **challenges** related to EIA and EP&R posed by the **novel modular nuclear technologies**
- The projects represent a synergic research framework able **to build a comprehensive guidance for EIA and EP&R** based on tight cross-links among state-of-the-art science in environmental and dose modelling and an extensive stakeholder and community engagement programme

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The GIROSCOPE and The CATAPULT Communities

- **CATAPULT**
  - 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)
- **GIROSCOPE**
  - D. Damien, I. Korsakissok (ASNR), Ch.Pölzl-Viol, C. Woda, M.Pattantyús-Ábrahám, T.Hamburger (BfS), L. Lebel (CNL), E. Lafranque, L. Boffa-Beltrami, P.Croüail, T. SCHNEIDER (CEPN), M. Montero (CIEMAT), M. Isaksson, V. Hansen, J. Sundström, P.Gunnarsson ,E. Bergbäck Knudsen (Gothenburg University), M. Skrzypek, A Wawrzynczak-Szaban, P. Kopka, S. Potempski (NCBJ), S. Andronopoulos (NSCR), D. Oughton, Y. Tomkiv (NMBU), P. Nunes (APA), A. Bexon, J. Sherwood (UKHSA)

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