PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 41st cycle

THEMATIC Research Field: RISK MODELLING AND RESILIENCE OPTIMIZATION OF COMPLEX ENERGY SYSTEMS AND PROJECTS

Monthly net income of PhDscholarship (max 36 months)
1500.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Systems for power generation, transmission and distribution are highly complex, as are their development projects. In all instances, deployment of capacity and systems performance are repeatedly undermined by emergent interactions that trigger disruptions. Large energy endeavors, such as nuclear and oil &gas facilities, are high-stakes: engineering, supply-chain, regulatory and contractual factors interact, design choices and configuration changes feed back into project plans and operational policies, and local disturbances can cascade with severe effects on both project objectives and systems performance. Risk assessment and resilience management aim to manage these scenarios by ensuring system's ability to plan and prepare for the potential occurrence of disruptive events, and then absorb, recover, and adapt in case of occurrence. However, many approaches still treat components and risks in isolation, overlooking interactions and propagation. Formal system representations make structure and interfaces explicit, providing the backbone for uncertainty propagation and for assessing systems' performance. Network theory provides a powerful framework to characterize interdependencies, capture how disturbances propagate across technical and organizational elements, and evaluate overall resilience, thereby informing design and planning decisions that

	reduce vulnerability and improve recoverability. From this foundation, machine learning supports stochastic/robust optimization of system design, project plans and operational policies. Recent advances in graph learning and adaptive re-planning, such as Graph Neural Networks and Reinforcement Learning, enable identification of critical pathways and optimization of systems performance. Taken as a whole, explicit structure, propagation insight and integrated optimization form the basis for developing meta-systems that describe and monitor, anticipate cascades and guide adaptive planning and recovery to optimize project and system performance under uncertainty.
Methods and techniques that will be developed and used to carry out the research	Model-based systems engineering, design structure matrix, network theory, topological analysis, monte carlo simulation, robust optimization, sequential decision-making, reinforcement learning, graph neural networks, surrogate modelling, stochastic optimization, evolutionary algorithms, multi-objective optimization
Educational objectives	To prepare a modern and professional expert in Risk and Resilience analysis of complex projects and systems, equipped with advanced technical skills of system analysis, modelling, simulation and artificial intelligence/machine learning.
Job opportunities	Risk analyst, risk engineer, project risk manager, systems engineer and resilience analyst with competences suited for the assessment of risk and resilience optimization in complex energy systems and large-scale infrastructure projects.
Composition of the research group	3 Full Professors 0 Associated Professors 1 Assistant Professors 18 PhD Students
Name of the research directors	Enrico Zio

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
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