



# PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 39th cycle

**THEMATIC Research Field: DESIGN AND ANALYSIS OF NUCLEAR ENERGY SYSTEMS FOR LUNAR SURFACE APPLICATIONS**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1400.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>Space activities devoted to the planets and satellites exploration represent both a formidable challenge and a tremendous boost for innovation. The Moon has become the main objective in space exploration targeting a human base and the development a permanent settlement. The Italian Space Agency highlights - among other challenges - the importance of energy production and transportation capability for the lunar missions. The exploration of the Moon requires huge energy resources for functioning of future installed infrastructures (housing modules, ISRU systems - in Situ Resource Utilization, etc.) on the satellite surface, in addition to surface rover and drone operation.</p> <p>Classic power generation systems - as solar panels and Radioisotope Power Generators - and energy storage devices - as battery - are not suited for long-duration lunar missions due to the low power density, low efficiency and limited operational. Micro-Modular nuclear Reactors can be an interesting optio to be adopted for power generation on the Moon due to the high density power, compactness, and the capability to operate for long time with high reliability. The research is aimed at studying a Moon Energy Hub able to generate, store and transport energy for the lunar missions based on a MMR.</p>



<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>The investigation will be mainly focused on the most promising MMR concept, i.e., the Heat Pipe Reactor (HPR). A holistic approach will be adopted, to address neutronic, thermalhydraulic, thermalmechanic, system and economic features. Safety and safeguards will be addressed as well. All the main reactor systems will be addressed: core and fuel, heat transfer, power conversion, heat rejection, control, maintenance, as well as the coupling with the Moon station energy system. The methods and techniques to be used will be mainly of numerical-modelling type. Among the state-of-the-art simulation codes: RELAP (safety), SERPENT (neutronics), OpenFOAM (fluid dynamics and thermal mechanics), FLUENT (CFD), MODELICA (object oriented modelling), COMSOL (Multiphysics), Matlab-Simulink (model predictive control). In-house models will be developed as well (e.g. for the economic analysis).</p>
<p><b>Educational objectives</b></p>	<p>The PhD student will develop an interdisciplinary approach devoted to address not only the key features of the reactor system (from neutronics to economics), but also the integration of the MMR into the energy system of the Moon station (e.g. power storage systems, wireless energy transmission systems, other energy generators, energy loads).</p>
<p><b>Job opportunities</b></p>	<p>The candidate's profile will be highly attractive both in the research environment, where crossdisciplinary skills are more and more appreciated, and in the expanding field of space applications design, analysis, and management.</p>
<p><b>Composition of the research group</b></p>	<p>1 Full Professors 2 Associated Professors 2 Assistant Professors 12 PhD Students</p>
<p><b>Name of the research directors</b></p>	<p>Stefano Lorenzi</p>

<b>Contacts</b>
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p><b>Increase in the scholarship for stays abroad:</b> euro 700 per month, for up to 6 months.</p> <p><b>Educational activities:</b> Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. This amount is equal to 10% of the annual gross amount, for 3 years.</p> <p><b>Teaching assistantship:</b> Availability of funding in recognition of supporting teaching activities by the PhD student. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.</p> <p><b>Computer availability:</b> individual use.</p> <p><b>Desk availability:</b> individual use.</p> <p><b>Awards:</b> Awards will be recognized to the PhD candidate up to Euro 1500 (gross amount) per year, in case of exceptional achievements in the research project, subject to the evaluation of the research director.</p>