Project Call for 2022 ERBE Cohort

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PhD Proposal Title:	Powering houses and apartment blocks with wastewater
Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)	This PhD proposal aligns with the theme **2. Technology and system performance**: development of *on site* and *in house* wastewater treatment systems to make houses and apartment blocks energy self-sufficient. By boosting (green) energy production from grey water and wastewater, this PhD proposal will contribute to providing energy security, to decarbonising the society and identify possible steps based on the water-energy nexus to progress the energy transition.

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PhD Proposal Abstract: (500 words max)	Within the context of the energy transition, there is little attention to the water-energy nexus. One of the aims of the EU energy policy is to make the EU a world leader in renewables. To this end, European heads of state and governments have committed to a renewable energy target of at least 27% by 2030. This PhD aims to explore how *on site* and *in house* wastewater treatment can contribute to this EU's renewable energy target. Wastewater is increasingly becoming a resource that can be utilised and contribute to the green and energy transition – thanks to new technologies and innovative thinking. On one hand, new technologies that save energy and make houses and plants more energy efficient are continuously implemented. On the other hand, new methods of producing energy – e.g. heat and biogas – constantly increase the productivity of these systems. Biogas from wastewater treatment is a clean energy source that has several advantages: i) it is dispatchable and, once upgraded, can be stored and distributed using the existing gas infrastructure network; ii) it does not rely on critical raw materials; iii) it does not disrupt wildlife and iv) it does not compete for agricultural land or put pressure on water bodies. Biogas can either be used to power the plant itself, or upgraded and fed into the grid as biomethane for use in heating and cooling and/or transport. Besides biogas production, there are other ways to extract energy from wastewater. An obvious energy source is the heat of the wastewater. At the moment, there is no infrastructure to use this heat, and how building blocks need to be adopted to make use of (waste)water heat is unknow. A redesign of homes would also be needed if we want to integrate bioelectricity production from wastewater in the electric circuit. Extraction of bioelectricity from wastewater by (microbial) fuel cells is well known, e.g. by modifying septic tanks or algal solar panels. But how these innovative power production units can be integrated within a house/apartment block architecture requires further research on maximising

	energy yields on the one hand and design thinking of integrated wastewater based power production units on the other hand. The recovery of energy from wastewater has been studied for centralised wastewater treatment systems. However, how energy recovery can be integrated at house or apartment block level is yet not well studied. This PhD project wants to demonstrate a range of lab-tested innovations for energy positive *on site* and *in house* wastewater treatment systems. At its heart, the concept is based on the conversion of organic matter in wastewater into biogas, biohydrogen or bioelectricity and subsequently supply these *in house* within the existing energy infrastructure. It will also result in recovery of a valuable resource- water and energy savings associated with centralised, large-scale wastewater treatment. The proposed research is very timely and in line with research and innovation aims of large stakeholders in the water-energy nexus. For example, Severn Trent Water, UK's second biggest water company, has identified solutions for scaled closed loop housing development for water and energy recovery as part of their priority innovation needs.

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PhD Proposal Summary for inclusion in Student Call Document: (300 words max – please note the student will be indicating their order of preference for all submitted proposals; please ensure this summary includes a project overview & introduction to the supervisor & institution)	Project highlights: • Analysis of how wastewater treatment can be integrated in the energy supply of a home or apartment block. • Design of grey water and combined sewage treatment train for on-site renewable energy production and use, including biohydrogen, biogas and bioelectricity. • System assessments of the proposed treatment trains by pinch analysis and Life Cycle Analysis. Project overview: The project will investigate how the water/energy nexus can be used to develop energy efficient or even self-sufficient buildings. The PhD student will exploit *on site* and *in house* renewable energy production from wastewater to provide the energy needs of a house or apartment block. The research will concentrate on experimental research at laboratory and pilot scale at both NUIG, Ireland and Loughborough, UK. In addition, some advanced simulations and numerical developments of the energy outputs, decarbonisation effects and life cycle impacts will be done, together with rigorous analysis and validation of results. The PhD will investigate research questions that come from scaling wastewater treatment systems and integrating energy recovery to the *on site* and *in house* level. These include: can this be applied to combined sewage and/or grey water? What is the wastewater treatment train that gives most reliable energy production? What design changes are needed within a house/apartment block to enable wastewater based energy production? Can a house become energy sufficient using this approach? What are the costs and the payback time of the systems? Introduction to the supervisor & institution: Piet Lens is an established Professor of New Energy Technologies at NUI Galway and Principal Investigator of RA5 of Marei (www.marei.ie/people/piet-

	lens/). Tanja Radu is a Senior Lecturer in Water Engineering, with more than 15 years of international experience in water and environmental engineering. Her main research interests include wastewater treatment, renewable energy from waste and supplying energy for rural communities in developing countries. She is also leading School's partnership with Severn Trent Water (www.lboro.ac.uk/departments/abce/staff/tanja-radu/#tab5).