Module no. M1 (New)	Geo-resources and Carbon impact
Module code and mode of delivery	Code: GL7003, Delivery: Blended Learning through Blackboard VLE/LMS, face-to-face teaching and tutorial discussions as appropriate (see below).
Module ECTS Weighting	10 ECTS
Semester of delivery	S1 + S2
Module Contact Hours	50 hours lectures (hybrid synchronous online and/or face-to-face). 80 hours independent student learning. 20 hours tutorials (hybrid synchronous online and/or face-to-face). 50 hours continuous assessment in the form of a desk study.
Module Coordinator	Prof. Juan Diego Rodriguez-Blanco.
Module teaching staff and academic titles	Profs. Sean McClenaghan and Juan Diego Rodriguez-Blanco.
Module description—content	During the last decades it has become clear that the ways of living that have evolved over the last century in developed countries, together with increasing world population, are not sustainable, perhaps leading to environmental disaster in the current century. Governments have realised the importance and urgency of moving towards sustainable ways of living. Notable examples include the establishment of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change via The Paris Agreement. It has become imperative to achieve the net-zero energy efficiency and this includes to find renewable, sustainable replacements for fossil fuels and, latterly, by the urgent need to use fuels which do not produce large quantities of greenhouse gases, notably CO_2, but also other (fluro)hydrocarbons. The main goal of this course is to provide necessary education in the importance of geological resources that serve as the basis for life in modern-day society and their carbon impact. Students will learn about the global geology and the natural occurrence of energy resources and extraction logistics of oil, uranium, conventional and unconventional (shale) natural gas, coal, ores as well as critical raw materials (metals). They will learn how to identify and evaluate raw materials deemed

	critical to the EU and the world and viable mining locations, methods of extraction, concentration, smelting and refining, as well as reclamation and decommissioning of mine sites. We will highlight the importance of mineral geochemistry and metallurgy to recover energy critical elements (Te, Ge, Se, Ga, Sb, Sn & In) from mine wastes, as well as the realities of recovering strategic elements from manufactured goods, resource cycles and market effects on mining and exploration sectors. The course will also introduce the carbon cycle and the students will learn the role of CO_2 in mineral-water interface geochemistry and its importance for natural and industrial processes. We will cover mineral-water reactions, kinetics and mechanisms of carbonate growth and dissolution, natural and industrial sources and CO_2 and other greenhouse gases and their importance in the carbon cycle. The students will learn the properties of CO_2, the importance of CO_2 in the atmosphere, hydrosphere and geosphere at geological timescales and the projected CO_2 levels in the future and potential consequences. We will cover the natural sources of CO_2 and the major sources of anthropogenic CO_2 emissions (e.g., fossil fuels, steel and cement plants). Students will be able to evaluate the advantages and disadvantages of the many different carbon capture and storage (CCS) technologies, from carbon capture from industrial processes (cement, steel, oil, natural gas) to mineral carbonation processes and biological capture and storage of CO_2, including new directions of research in CCS technology and time frame for new technology implementation.
Module learning aims/objectives	The key objectives are as follows: • To understand what the environmental consequences of current and future energy utilisation are expected to be. • To understand important environmental mitigation procedures for the consequences of energy utilisation and how effective these can be, from a science and implementation viewpoint. • To relate physical and chemical factors which affect the carbon cycle at multiple length and timescales to implications for global climate change and technological readiness on carbon capture and storage. • To apply science underlying conventional and sustainable energy sources including fossil, wind, solar, biomass and biofuels to propose solutions to the clean and sustainable energy problem.

Module learning outcomes	On successful completion of this module, students should be able to: MLO1.1. To introduce Global geology, critical raw materials and their role. MLO1.2. To describe the distribution of conventional energy natural resources (Uranium, Coal, Gas & Oil) and critical raw materials in the earth's crust and devise strategies for the minimal impact extraction of a resource. MLO1.3. To perform life-cycle analysis of energy relevant raw materials. MLO1.4. To introduce Earth and the carbon cycle: properties of CO_2, CO_2 in the atmosphere, in freshwater and seawater, climate change and natural carbonation processes. MLO1.5. To outline the natural and anthropogenic role of CO_2 in the carbon cycle, the projected trends in its concentration and the expected environmental consequences of this. MLO1.6. To explain and compare various technologies for carbon capture and storage.
Module assessment, separate components and their weighting to be mapped into SITS	Desk study: 50%. Exam Paper 5 (2 questions): 50%.