PhD in Chemical Sciences *Department of Chemistry “Ugo Schiff” University of Florence*

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PhD course “**Energy saving, decarbonisation and hydrogen as an energy vector**”

**SYLLABUS**

**1 Lecturer A, information**

**Name and Surname**: Caterina Rizzo and Alberto de Angelis

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**2 Title of the seminar A**

The technology leverage towards decarbonization: the priority areas for Eni’s R&D

**1 Lecturer B, information**

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**2 Title of the seminar B**

Additives for Energy-Saving Lubricants with a low environmental impact

**1 Lecturer C, information**

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**2 Title of the seminar C**

Hydrogen, a new energy vector: grey, green or blue

**1 Lecturer D, information**

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**2 Title of the seminar D**

CCUS – Carbon Capture, Use, and Storage

**3 Course program**

The course begins with a lecture presenting the different aspects developed at Eni to overcome the production of energy from fossil fuels and mitigate the CO2 production. A panorama of different technologies for the production of renewable energy is presented; this first lecture, therefore, is an introduction to the following ones in this course and also to other courses that will be presented within the PhD programme, where different technologies that can help with energy sustainability and environmental protection will be developed point by point. The following three lectures deal in more detail with specific fields: the first deals with the effect of environmentally friendly lubricants in saving energy. The second deals with the energy vector hydrogen, illustrating the merits and demerits of this element and the future possibilities of using it to power particularly energy-intensive industrial plants. the last one focuses on an extremely important aspect, which is the capture, use and storage of CO2. Thus, more generally, this course presents industrial opportunities in the field of energy-saving decarbonisation and the use of hydrogen as an energy carrier, presenting innovative experimental research.

**4 Course content detailed per lesson of two hours (possibly with dates and room real and virtual)**

* **Lesson 1** – aula 186 Zvi Jolles and online, 24-09-2024 - from 14:00 to 16:00

The need to strongly accelerate decarbonization is the key factor in leading the world - and the energy sector in particular - along the trajectory outlined by a sustainable development scenario, according to the objective of the Paris Agreements. Decarbonization is a strategic priority for Eni which has as its goal net zero emissions from the upstream business by 2030 and net zero emission Scope 1+2+3 by 2050. Eni’s R&D has identified key areas of high-impact technological development for the reduction and zeroing of CO2 emissions: some technological solutions are already under development, while others are close to industrial deployment.

* **Lesson 2** – aula 186 Zvi Jolles and online, 30-09-2024 - from 11:00 to 13:00

The lubricants are a mixture of base oils and additives, added to obtain the desired performances in the finished products. The main classes of additives will be illustrated, principally those involved in the current technological evolution of lubricants. This evolution is directed towards products that contribute to improving the energy efficiency of engines and machinery, engine lubricants highly compatible with the after-treatment devices (particulate traps and catalytic converters) and products deriving from bio-renewable sources. Some classes of innovative additives that have been developed and are being studied in our laboratories will be illustrated. These additives will allow us to face the technological evolution of the sector and are in line with Eni's decarbonization strategy.

* **Lesson 3** – aula 186 Zvi Jolles and online, 01-10-2024 - from 14:00 to 16:00

Hydrogen has experienced cycles of high expectations followed by impractical realities. However, a series of technological advances and political and environmental factors offer tangible prospects today, giving hydrogen a realistic potential in the context of the Great Transition.

The Green Deal puts the EU on a path to climate neutrality by 2050, through the deep decarbonisation of all sectors of the economy, and higher GHG reductions for 2030. This objective presents several challenges, and it will require a radical transformation not only in how we generate, but also in how we distribute, store, and consume energy.

At the center of this ambitious project, the EU has placed electrification of course but also hydrogen, which is seen as a versatile, clean and flexible energy vector to achieve this goal.

The EU’s energy transition requires almost completely decarbonized power generation. The solution is to develop a new energy mix with more renewable energy, which implies integrating renewables into the grid and managing their intrinsic variability. The high penetration of renewables will create imbalances in the supply/demand market and this creates the need for a balancing across the year and seasonal energy storage. Hydrogen, if produced with a low carbon footprint, is a good candidate for this role, because it allows the conversion between different forms of energy.

* **Lesson 4** – aula 186 Zvi Jolles and online, 11-11-2024 - from 11:00 to 13:00

Carbon Capture, Utilization, and Storage (CCUS) is a critical technology in the global decarbonization strategy, aimed at reducing greenhouse gas emissions from industrial sources and power generation. It involves capturing CO2 emissions at their source, transporting them, and either storing them underground in geological formations or utilizing them in various industrial processes, such as in the production of synthetic fuels, chemicals, or enhanced oil recovery.

CCUS is essential for decarbonizing hard-to-abate sectors like cement, steel, and chemical manufacturing, where emissions are difficult to eliminate entirely. By preventing CO2 from reaching the atmosphere, CCUS enables industries to continue operating while transitioning to cleaner energy sources. Additionally, it supports the development of a circular carbon economy, where captured CO2 is recycled into useful products, reducing the need for new fossil carbon inputs. As part of a comprehensive climate strategy, CCUS can help achieve net-zero emissions by complementing other technologies like renewable energy and energy efficiency. The talk covers the Carbon Capture Usage and Storage (CCUS) from an industrial perspective. Starting from the reasons why the CCUS is considered a significant leverage for the decarbonization of the energy mix from today to 2050, a key date in the scenario of the energy transition, the different technical sections of the CCUS are tackled and briefly analyzed.

The key chemical-physical principles of CO2 capture from different streams are presented followed by a review of the main technologies that deploy these principles.

Since the capture point is typically far away from the storage site, the transportation solutions either continuous (i.e. pipeline) or discontinuous (ship, train) are briefly reviewed.

The two final alternatives – storage or utilization – constitute the final part of the chain although typically quite different in volume: the utilization is predicted to be much lower than the volume available demanding therefore for large volume storage.

The studies and modelling of storage sites, either depleted reservoirs or aquifers, are described at a high level highlighting the key elements to ensure safe and long-term storage. The last part is dedicated to the utilization of CO2 as a building block for products touching the key criteria framing the CO2 utilization.

**5 Suggested reading**

Suggestions for readings and deepening of the treated arguments are present in the slides, that are available to the doctoral students.

**6 Learning Objectives**

The learning objectives that the course aims to achieve is to provide an overview of the research and development of materials and the approach to certain environmental issues, from the point of view of industrial research. The course will be useful for the student to see what are the guidelines that orient a company towards a particular type of research and what are the dynamics, scientific, technological, economic, and productive with which this is decided. It will be useful for the student to have an overview of what the labour market, outside the academy, can offer, and what are the major challenges that are now being faced by both public governance and the industrial component of European society.

**7 Knowledge and Skills to be acquired**

In general, in this course, the student is expected to gain knowledge about how research is carried out in industries, whether small, medium-sized or multinational and to compare it with how academic research is carried out. Hence, a comparison between basic and applied research and the interconnections present and necessary between these. The course will also highlight the importance of intellectual protection, both at the academic and industrial levels, and will give some rudiments on how to exploit it, what can be patented, what can be done when one does not have the rights to a patent, all seen from the perspective of the best exploitation of industrial research.

A further aspect introduced, which relates to the world of materials, is that of their recycling and the sustainability of their production; general aspects of material recycling will be presented and some specific cases will be explored in depth, to give the student information on what could be a very large job sector developing shortly.

**8 Prerequisites**

General bases of chemistry or material technologies or materials engineering applied to the industrial research

**9 Teaching Methods**

 MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

**x** MODE 2 (preferred) - Lessons delivered in-person and in remotely with simultaneous recording by the Google Meet platform.

**10 Further information**

**11 Type of Assessment**

Written examination at the end of the classes with open and closed questions.

**12 Period**

24-10-2024 – From 14:00 to 16:00

30-10-2024 – From 11:00 to 13:00

01-10-2024 – From 14:00 to 16:00

11-11-2024 – From 14:00 to 16:00

Exam: TBD