UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	ENERGETIC AND NUCLEAR ENGINEERING
SUBJECT	HYDROGEN AND ELECTRO-CHEMICAL ACCUMULATION SYSTEMS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20927-Attività formative affini o integrative
CODE	19658
SCIENTIFIC SECTOR(S)	ING-IND/23
HEAD PROFESSOR(S)	INGUANTA ROSALINDA Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**INGUANTA ROSALINDA** Tuesday 15:00 18:00 Studio Secondo Piano ed. 6 Thursday 15:00 18:00 Studio Secondo Piano ed. 6

DOCENTE: Prof.ssa ROSALINDA INGUANTA

PREREQUISITES	Fundamentals of Chemistry, Thermodynamics, Electrotechnics
LEARNING OUTCOMES	1) Knowledge and ability to understand The student will know the operating principles and the structure of the different types of fuel cells, batteries and electrolyzers. It will be able to understand the technical and energetic problems that recommend the use of a Fuel Cell, battery or electrolyzer. 2) Ability to apply knowledge and understanding The student will be able to understand and choose the type of fuel cell, battery or electrolyzer suitable for different applications. It will also be able to intervene in the manufacturing processes of the various generators and storage systems and to design integrated systems for power generation and storage. 3) Autonomy of judgment The student will be able to establish the procedures suitable for choosing the most suitable electrochemical device according to the local energy situation and the geographical position. 4) Communication skills The student will be able to communicate with other technical figures and experts in the field of manufacturing devices for energy generation and storage, both for traditional systems and for renewable energy. 5) Learning skills Ability to update with the consultation of the scientific publications of the sectors of the generation and storage of energy and materials.
ASSESSMENT METHODS	The student's assessment takes place through an oral test to ensure that the knowledge and skills provided by the course are available. Excellent knowledge and total mastery of the topic of the course. Student is able to apply knowledge to solve the proposed problems: 30-30 + L Good knowledge of the topics of the course, Student has some uncertainty but is able to apply knowledge to solve the proposed problems: 27-28 Discreet knowledge, Student need to be routed to solve the proposed questions: 23-26 Student has a minimal knowledge of the main topics of the douse. Partially not self-sufficient to apply the knowkledge: 18-22
EDUCATIONAL OBJECTIVES	The goal of the course is to provide a basic knowledge on thermodynamical and kinetic law governing fuel cells, batteries and electrolyzes. Engineering knowledge of the different kinds of generator. Scale-up.
TEACHING METHODS	The course takes place in the second half of the first year and consists in: Lessons, Numerical applications in Laboratory, Seminars
SUGGESTED BIBLIOGRAPHY	“The hydrogen economy”, The National Academies Press (2004), ISBN: 978-0-309-09163-3. J. Larminie, A. Dicks, “Fuel Cell Systems Explained”, Wiley (2003), SBN: 978-1-118-87833-0. M. Broussely, G. Pistoia, Industrial Applications of Batteries, ISBN: 978-0-444-52160-6

SYLLABUS

Hrs	Frontal teaching
1	Presentation of the course.
3	Hydrogen economy.
7	Industrial methods for hydrogen production. Steam reforming. Partial oxidation. Gassification. Purification processes syn-gas for the production of pure hydrogen.
3	Hydrogen storage. Physical and Chemical methods. Hydrogen carriers.
12	Galvanic systems: description, transport in ionic conductors, thermodynamical laws. Limit and real efficiency of a fuel cell. I-V characteristics of FC. Dissipations: activation, internal current, fuel cross-over, ohmic and transport losses.
14	FC stacks. Different types of FC and their applications. Comparison figures. Detailed study of PEMFC and their uses. Seminar and Laboratory Exercise on Microbial Fuel Cell. Seminar and Laboratory Exercise on PEM. Alkaline and Direct methanol fuel cells. FC for intermediate and high temperatures. Bottoming cycles. Phosphoric acid FC. MCFC. SOFC.
4	Electrolyzers: i-V curve, Alkaline, PEM, AMEL and SOEC.
4	Battery for energy storage: general features, battery chemistry and components, charge and discharge cycles. Basics on super capacitors and comparison with batteries. Safety. Lead acid batteries, vanadium redox flow batteries, lithium and lithium-ion batteries.

Hrs	Workshops
2	Laboratory Exercise on PEM FC
4	Laboratory Exercise on electrolyzes.