

GREEN HYDROGEN AND ITS APPLICATIONS

 Executive Master |  12 months |  English |  Benguerir Campus

UM6P

 EXECUTIVE
EDUCATION

LIMSET
Laboratory of Inorganic
Materials for Sustainable
Energy Technologies



Message from the Director



« We are delighted to announce the second edition of our Executive Master Program, building upon the resounding success of the inaugural edition. This program remains dedicated to the exploration and advancement of green hydrogen and its multifaceted applications. Designed to provide participants with a robust foundation, this edition delves deeper into the evolving landscape of hydrogen production technologies, with a delicate focus on the innovations driving the production of green hydrogen.

Participants will continue to engage with the technical details of handling, storing, and transporting hydrogen, while also gaining valuable insights into the pivotal role of fuel cells across various sectors. Moreover, this edition will further enrich participants' understanding of hydrogen safety protocols and the nuanced interplay of policy and strategy crucial for fostering the hydrogen economy.

Whether you're an industry professional seeking to stay up-to-date of the latest developments or an aspiring enthusiast willing to carve a niche in the hydrogen industry, this program is tailored to meet your evolving needs. Join us in this transformative journey and become a catalyst for change in the ever-expanding domain of green hydrogen.

Enroll today and be at the forefront of shaping a sustainable energy future!»

Pr Abdessamad Faik

Full Professor at Mohammed VI
Polytechnic University
and LIMSET Director

UM6P - University Mohammed VI Polytechnic



University Mohammed VI Polytechnic is an institution focused on applied research and innovation. With its focus on Africa, it aims to rank among the world's leading universities in these fields.

Committed to economic and human development, the University puts research and innovation at the service of the development of the African continent.

This positioning enables it to consolidate Morocco's avant-garde position in these fields, through the implementation of a unique partnership approach and the reinforcement of the training offer in skills relevant to Africa's future.

With its outstanding faculty, cutting-edge research facilities, global partnerships and thriving entrepreneurial ecosystem, UM6P is an innovative hub, reflecting the world beyond, with its challenges, prospects and promises.

Located in the commune of Benguerir, close to Marrakech, in the heart of the Mohammed VI Green City, the University Mohammed VI Polytechnic aims to shine on a national and international scale.

Empowering Minds.



University
Mohammed VI
Polytechnic

Executive Education Science & Technology



The Executive Education Science & Technology (Exed S&T) program at University Mohammed VI Polytechnic (UM6P) supports executive leaders in Morocco and Africa in their development goals through diverse training programs led by recognized experts. Focused on science and technology domains such as digital, sustainable development, mining, renewable energy, Industry 4.0, and more, these courses enable participants to gain advanced knowledge and develop unique expertise in the market. This is achieved through a favorable, flexible, creative, and stimulating learning environment that encourages practical application through business cases. Centered around science and technology, these programs align with UM6P's pedagogical project, bringing it closer to the realities of professionals. They also rely on high-quality multidisciplinary scientific research.

An Ecosystem for Research, Innovation, and Real-Scale experimentation



LIMSET – UM6P



LIMSET, the Laboratory of Inorganic Materials for Sustainable Energy Technologies, is dedicated to advancements in sustainable energy through innovative research and training. Our focus lies in the design, development, and optimization of inorganic materials for various sustainable energy processes. We work diligently to contribute to the competitiveness of Moroccan and African companies by conducting research across a wide range of applied sciences.

Our main activities turn around key pillars of sustainable energy. We explore into renewable energy, exploring ways to maximize its potential and effectiveness. Additionally, we are committed to advancing thermal energy storage technologies, all-solid-state batteries, green hydrogen and green ammonia production and storage methods.

Through these activities, LIMSET plays a crucial role in shaping a cleaner, more sustainable energy future for Morocco, Africa, and beyond.



Program



Objective

The Executive Master in Green Hydrogen and its Applications is meticulously crafted to equip industry leaders with the essential skills and knowledge needed to excel in the rapidly increasing field of green hydrogen and green ammonia technologies. Our comprehensive curriculum encompasses both fundamental principles and technical details, ensuring participants gain a deep understanding of hydrogen production, storage, and transportation methods. Moreover, we delve into critical areas such as safety pro-

ocols, regulatory frameworks, and strategic business considerations vital for navigating the complexities of a hydrogen economy.

Participants of our program will engage with cutting-edge insights and practical applications, empowering them to tackle the multifaceted demands of the industry with confidence and expertise. Through collaborative learning and expert guidance, our aim is to cultivate a cohort of visionary leaders composed to shape the future of green hydrogen and its applications.

Key elements

- **Fundamentals for the existing industrial technologies of the hydrogen production.**

- **Current and emerging options for the production of green hydrogen.**

- **Technical options for handling, storing and transporting hydrogen.**

- **Key characteristics and drivers for the production of green molecules.**

- **Fuel cells and their roles in transportation, in the electric grid, and in domestic and commercial power supply.**

- **Basics & fundamentals of hydrogen safety.**

- **Non-technical challenges for the adoption of hydrogen-based technologies, such as market and social factors.**

- **Policy and strategy: critical factors in building the hydrogen economy.**

Program



Eligibility & Requirements

The program is open to both Moroccan and international candidates.

Hold a Bachelor's degree in Engineering or a related field.

Work experience in the field of energy is a plus.

Technical background in Chemistry or Physics is encouraged.

A minimum of 2 years of work experience is required.

Fluency in English/French is desirable.

Program



MODULE	CASE STUDY
Fundamentals of hydrogen technology and production processes	Environmental impacts
Green hydrogen production technologies and emerging options	Tutorials on PEM and Alkaline Electrolyzers
Technical options for handling, storing, and transporting hydrogen	Exploring Solid-State Storage of H₂
Green Molecules Synthesis Green Ammonia	Tutorial on Haber-Bosch process
Fuel cells and their applications in transportation, power generation, and industry	Fuel cells' application in mobility
Safety, regulatory, and environmental considerations for hydrogen technologies	Balancing Safety and Innovation
Business Methods, Policy, and strategy for developing a hydrogen economy	Developing a Hydrogen Factory Business Plan
Master's Final Project	Innovating in a Traditional Industry

Program

Module 1: Fundamentals of hydrogen technology and production processes

This module covers the basics of hydrogen technology, including its physical and chemical properties, hydrogen production process. It explores the current state, and key challenges of the current industrial technologies. It also highlights the market size, benefits, and major R&D needs for each technology.

The following elements will be covered:

- Understanding the properties, classification, benefits, and challenges of hydrogen as an energy carrier.
- Exploring the current landscape of hydrogen production facilities and their crucial role in sustainability efforts, pollution reduction, and combating climate change.

Module 2: Green hydrogen production technologies and emerging options

This module focuses on green hydrogen production technologies, such as electrolysis and biomass gasification, as well as emerging options such as photoelectrochemical, thermolysis and biological processes.

This module will delve into the following elements:

- Classification of green hydrogen production methods: Thermal, electrical, hybrid, and biological approaches.
- Understanding the fundamentals of green hydrogen production methods, including principles, mechanisms, and materials involved.
- Thermodynamic analysis of green hydrogen production processes, covering basic thermodynamics and the thermodynamics of electrolysis.

- Acquiring fundamental knowledge of hydrogen production technologies, encompassing both conventional and advanced industrial processes.
- Analyzing the advantages and challenges inherent in current industrial hydrogen production technologies, including efficiency, cost, and environmental impact considerations.
- Introduction to diverse methods of hydrogen production and utilization, alongside an examination of their environmental implications.

Case Study: Environmental impacts

Analysis the environmental impacts of different hydrogen production methods. This includes an analysis of the carbon footprint, energy consumption, and waste generation associated with various technologies. This case study will provide insights into the importance of sustainable and eco-friendly hydrogen production technologies for mitigating climate change and promoting environmental stewardship.

- Comparison of theoretical efficiencies among different green hydrogen production methods to assess viability and potential for optimization.
- Identifying opportunities for innovation and improvement in green hydrogen production processes to enhance efficiency and sustainability.

Case Study: Tutorials on PEM and Alkaline Electrolysers

To provide participants with an in-depth understanding of these two commonly used electrolysis technologies, covering the operating principles, materials, components and designs. The tutorial will also include a comparison of the advantages and limitations of each technology. By the end of the tutorial, participants will be equipped with the knowledge and skills needed to evaluate the performance and suitability of PEM and alkaline electrolysers for different hydrogen production scenarios.

Program

Module 3: Technical options for handling, storing, and transporting hydrogen

This module delves into the technical options for handling, storing, and transporting hydrogen, including compression, liquefaction, and solid-state storage methods.

This module will delve into the following elements:

- Classification of green hydrogen production methods: Thermal, electrical, hybrid, and biological approaches.
- Understanding the fundamentals of green hydrogen production methods, including principles, mechanisms, and materials involved.

- Thermodynamic analysis of green hydrogen production processes, covering basic thermodynamics and the thermodynamics of electrolysis.
- Comparison of theoretical efficiencies among different green hydrogen production methods to assess viability and potential for optimization.
- Identifying opportunities for innovation and improvement in green hydrogen production processes to enhance efficiency and sustainability.

Case Study: Tutorials on PEM and Alkaline Electrolysers

To provide participants with an in-depth understanding of these two commonly used electrolysis technologies, covering the operating principles, materials, components and designs. The tutorial will also include a comparison of the advantages and limitations of each technology. By the end of the tutorial, participants will be equipped with the knowledge and skills needed to evaluate the performance and suitability of PEM and alkaline electrolysers for different hydrogen production scenarios.

Module 4: Green Molecules Synthesis and Green Ammonia

This module explores the synthesis of green molecules, such as green ethanol, methanol, and E-Fuels, which is produced using hydrogen as a feedstock. It also covers the production of green ammonia, which is gaining popularity as a carbon-free fertilizer and energy carrier.

This module will delve into the following elements:

- Introduction to hydrogen conversion technologies into valuable green molecules like methanol, ethanol, and ammonia, emphasizing their role in sustainable energy production.
- Exploration of green molecules markets, properties, and applications, including an overview of their significance in various industries.
- Overview of production, storage, and distribution

processes for green ammonia, highlighting its use as a medium for hydrogen storage and an energy vector.

- Techno-economic analysis of production, storage, and distribution systems for green ammonia, assessing their viability and potential for commercialization.
- Importance of green molecules and green ammonia integration in industries, emphasizing the synergies and opportunities for advancement.

Case Study: Tutorial on Haber-Bosch process

To provide participants with an in-depth understanding of the process for producing ammonia from hydrogen and nitrogen. Participants will learn about its operating principles, catalyst and designs involved. The case study will also explore the advantages and limitations of the Haber-Bosch process, including its energy efficiency, and economic viability. By the end of the case study, participants will be equipped with the knowledge and skills needed to evaluate the performance and suitability of the Haber-Bosch process.

Module 5: Fuel cells and their applications in transportation, power generation, and industry

This module covers the various types of fuel cells and their applications in transportation, power generation, and industry, including stationary fuel cells for buildings and portable fuel cells for consumer electronics.

This module will delve into the following elements:

- Introduction to fuel cell technologies, including their working principles, types, main development constraints, and future market prospects.
- Industrial practices for producing fuel cells, stacks, and modules, along with considerations for security and safety issues.
- Context of fuel cell use in mobility, highlighting

Module 6: Safety, regulatory, and environmental considerations for hydrogen technologies

This module examines the safety, regulatory, and environmental considerations of hydrogen technologies, including the safe handling and storage of hydrogen, regulations governing hydrogen production and transport, and the environmental impacts of hydrogen use.

This module will delve into the following elements:

- Examination of industrial and national frameworks or programs concerning hydrogen safety, covering properties and hazards of hydrogen and general aspects of hydrogen safety.
- Overview of safety standards for hydrogen production, including ISO standards addressing mate-

main limitations and advantages of fuel cell vehicles compared to traditional combustion engines.

- Overview of hydrogen engine technologies and emerging trends in combustion technology development.
- Working principle of a hydrogen internal combustion engine, focusing on the chemical characteristics of hydrogen and their influence on mixing, ignition, combustion, and performance.

Case Study: Fuel cells' application in mobility

To provide participants with an understanding of how fuel cells are used in transportation, specifically in vehicles such as cars, buses, and trains. Participants will learn about the advantages and limitations of fuel cell vehicles compared to battery-based electrical vehicles. By the end of the case study, participants will be able to evaluate the performance and suitability of different types of fuel cells for transportation applications, and to identify opportunities for innovation and improvement of fuel cell vehicles.

rials for hydrogen service, facilities, storage vessels, piping, and components.

- Discussion of safety standards for hydrogen transportation, outlining regulations and protocols to ensure safe handling and transport of hydrogen.
- Strategies for mitigation, prevention, risk reduction, and emergency procedures related to hydrogen safety, emphasizing proactive measures to address potential hazards.

Case Study: Balancing Safety and Innovation

To focus on balancing safety and innovation in the hydrogen industry. To explore real-world scenarios where the safe handling and storage of hydrogen are crucial, as well as the regulatory and environmental considerations that need to be taken into account. The case study will provide an opportunity to analyze and evaluate the risks and benefits of various hydrogen technologies and their potential impact on safety and the environment. The case study will also examine the role of industry stakeholders, policymakers, and regulators in ensuring the safe and sustainable development of the hydrogen economy.

Module 7: Business Methods, Policy and strategy for developing a hydrogen economy

This module explores the business methods, policy, and strategies for developing a hydrogen economy, including the development of hydrogen infrastructure, government incentives for hydrogen adoption, and public-private partnerships.

This module will delve into the following elements:

- Examination of government policies and incentives for hydrogen adoption globally, focusing on tax credits, subsidies, grants, and regulatory frameworks.
- Analysis of the economic and environmental benefits and challenges associated with transitioning to a hydrogen economy, considering factors such as emissions reduction, energy security, and economic growth.

Module 8: Master's Final Project

This module provides an opportunity for students to apply the knowledge gained throughout the program to a real-world problem or project related to green hydrogen and its application. The project may involve research, analysis, and the development of a solution or proposal for a specific issue or challenge.

This module will delve into the following elements:

- Opportunity for participants to apply knowledge gained in the program to real-world problems or projects related to green hydrogen and its applications.
- Emphasis on deepening participants' knowledge in a specific area of research within the field of green hydrogen technology.
- Integration of skills and competencies developed

- Exploration of successful hydrogen projects, exploring their business models, financing strategies, and risk management approaches to inform future initiatives.
- Examination of current and future market demand for hydrogen and its various applications across industries such as transportation, energy storage, and industrial processes.
- Analysis of cost-benefit ratios of hydrogen technologies compared to other energy sources, evaluating their potential impact on the overall economy and energy landscape.

Case Study: Public-Private Partnerships

To focus on the development of a hydrogen factory business plan and explores the challenges and opportunities associated with building a sustainable hydrogen economy. This case study will provide practical insights into the business methods, policy, and strategies. It will also evaluate the environmental and economic benefits of the hydrogen factory, including its potential to reduce greenhouse gas emissions, improve air quality, and create jobs in the hydrogen sector.

throughout the master's program to address complex challenges effectively.

- Engagement in research, analysis, and development of solutions or proposals for specific issues or challenges in the field of green hydrogen technology.
- Application of critical thinking, problem-solving, and innovative approaches to address real-world problems in the field.

Case Study: Innovating in a Traditional Industry

To examine how existing businesses can use hydrogen to improve their operations, reduce emissions, and meet sustainability goals. To prompt the candidate to think about how they can use the knowledge and skills they have gained throughout the master's program to innovate in their own industry. Candidates will be encouraged to identify a specific issue or challenge in their industry that could be addressed through the use of hydrogen technologies, and to develop a proposal for a solution or project that integrates hydrogen.

Testimonials

«The Executive Master in Green Hydrogen and its Applications offers tremendous value. As a Senior Project Manager in the Green Hydrogen & Ammonia program, I'm deeply grateful for the opportunity to participate in its first edition. The instructors were not only knowledgeable but also engaging, and the staff was collaborative, helpful, and enthusiastic. These classes provided a high level of interaction and offered valuable information and insights that I could directly implement in my professional role.»

Issam FARSS
Senior Project
Manager - INNOVX



«Though this testimony, I express both my satisfaction and deep gratitude for a enriching educational journey. The UM6P «Green Hydrogen & its Applications» Master's program, expertly designed by the Limset team delivered by high-level speakers from different nationalities. All, those elements provided me with a comprehensive, clear, and precise understanding of this new and promising sector. The diversity of the speakers and the conducive environment for knowledge exchange significantly enriched my learning experience, opening up new horizons for a promising career in the energy transition ecosystem.»

Abdellah ET-TOUALY
Project Manager-OCP



Learning Environment



New, fully-equipped facilities

The UM6P campus has been designed to stimulate scientific, cultural, sporting and artistic emulation, with all facilities open to the University community. Spread over 33 hectares in the heart of the future green city of Benguerir and close to Marrakech, the UM6P campus plans to reach 60 hectares by 2025. The UM6P campus has been designed by world-renowned architects whose work is based on sustainable development and the use of local techniques and materials.

Food and beverage outlets

There are a number of catering options available on the University campus throughout the day, for breakfast or just to share a coffee: restaurants, cafeterias, food trucks,

Accommodation options

UM6P is committed to providing you with a comfortable and secure place to live. High-speed internet access and a telephone line are provided in all accommodation.

The residences have a relaxation room with television, and a games room with billiards, table soccer and table tennis. A laundry service (washing machines and dryers) is available in each residence.

Rooms are available for disabled guests.

Sports activities

- 4 multi-sports fields (tennis, basketball, handball and volleyball)
- 1 NBA-approved basketball court
- 2 mini soccer turf pitches
- 25-meter semi-Olympic swimming pool and training pool
- A fitness room
- A weight room
- A dance studio
- A martial arts room



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