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**Design of a Decarbonized Ammonia Production
Unit via Electrolysis**

Prepared by: **BAKIR Sarah**

Supervised by: **Dr. TADJINE Soumaya (ENP)**
Mr. BOUCHENEB Djallal (SONATRACH)

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Jury Members:

President	Dr. MAAMRI Rachide	ENP
Supervisor	Dr. TADJINE Soumaya	ENP
Co-supervisor	Dr. TURAN Volkan	Tilia Company
Examiner	Dr. KHALDI Fouad	ENP

المخلص

يهدف هذا المشروع إلى تقييم الجدوى التقنية والاقتصادية لإنتاج الأمونيا الخضراء في الجزائر اعتماداً على الهيدروجين الأخضر المنتج بواسطة التحليل الكهربائي للماء باستخدام الكهرباء المتجددة. تمت دراسة منظومة Power-to-Ammonia تربط بين إنتاج الكهرباء من الطاقة الشمسية الكهروضوئية وطاقة الرياح في موقع الأغواط جنوب غرب، وإنتاج الهيدروجين في المنطقة الصناعية بأرزيو عبر الشبكة الكهربائية الوطنية. تم تطوير نموذج محاكاة زمني بدقة ساعة واحدة على مدار سنة كاملة (8760 ساعة) لتحليل إنتاج الكهرباء المتجددة، وتشغيل المحلل الكهربائي، وإدارة تخزين الهيدروجين، وإنتاج الأمونيا. كما تمت مقارنة أربع تهيئات مختلفة تشمل تقنيتي التحليل الكهربائي القلوي (ALK) وغشاء التبادل البروتوني (PEM) باستطاعتتي 20 و 50 ميغاواط. وأجري تقييم تقني واقتصادي اعتماداً على مؤشرات الأداء الرئيسية مثل إنتاج الهيدروجين والأمونيا، معامل الاستغلال، نسبة الإتاحة، تكلفة الهيدروجين المستوية (LCOH) وتكلفة الأمونيا المستوية (LCOA)، بهدف تحديد التهيئة الأكثر ملاءمة لدعم إزالة الكربون من صناعة الأمونيا في الجزائر.

الكلمات المفتاحية: الأمونيا الخضراء، الهيدروجين الأخضر، Power-to-Ammonia، التحليل الكهربائي للماء، PEM، ALK، تخزين الهيدروجين، الطاقة الشمسية، طاقة الرياح، LCOA، LCOH، إزالة الكربون.

Résumé

Face aux enjeux de décarbonation de l'industrie chimique, l'ammoniac vert apparaît comme une solution prometteuse pour réduire les émissions associées à la production conventionnelle d'ammoniac. Ce projet étudie l'intégration d'hydrogène vert dans une unité existante de synthèse Haber-Bosch située à Arzew, alimentée par une production électrique renouvelable hybride photovoltaïque-éolienne implantée à Laghouat Sud-Ouest et injectée dans le réseau électrique national. Un modèle horaire Power-to-Ammonia a été développé afin de simuler la production d'électricité renouvelable, l'électrolyse de l'eau, le stockage d'hydrogène et la production d'ammoniac sur une année complète. Quatre configurations combinant les technologies d'électrolyse PEM et alcaline avec des capacités de 20 MW et 50 MW ont été évaluées. Les performances techniques ont été analysées à travers la production d'hydrogène et d'ammoniac, le facteur de charge, le comportement du stockage et la disponibilité du procédé. Une évaluation technico-économique basée sur le CAPEX, l'OPEX, le coût actualisé de l'hydrogène (LCOH) et le coût actualisé de l'ammoniac (LCOA) a permis d'identifier la configuration la plus adaptée pour une intégration progressive de l'hydrogène vert dans l'industrie ammoniacale algérienne.

Mots-clés : Ammoniac vert, Hydrogène vert, Power-to-Ammonia, Électrolyse PEM, Électrolyse alcaline, Énergies renouvelables, LCOH, LCOA.

Abstract

In response to the decarbonization challenges facing the chemical industry, green ammonia has emerged as a promising solution for reducing emissions associated with conventional ammonia production. This project investigates the integration of renewable hydrogen into an existing Haber-Bosch ammonia synthesis unit located in Arzew, supplied by a hybrid photovoltaic-wind renewable energy system installed at the Laghouat South-West site and connected through the Algerian power grid. An hourly Power-to-Ammonia simulation model was developed to represent renewable electricity generation, water electrolysis, hydrogen storage, and ammonia production over a full year. Four configurations combining PEM and Alkaline electrolyzer technologies with capacities of 20 MW and 50 MW were evaluated. Technical performance was assessed through hydrogen and ammonia production, capacity factor, storage behavior, and process availability. A techno-economic assessment based on CAPEX, OPEX, Levelized Cost of Hydrogen (LCOH), and Levelized Cost of Ammonia (LCOA) was then conducted to identify the most suitable configuration for the progressive integration of green hydrogen into the Algerian ammonia industry.

Keywords: Green ammonia, Green hydrogen, Power-to-Ammonia, PEM electrolysis, Alkaline electrolysis, Renewable energy, LCOH, LCOA.

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