

DEMOCRATIC AND POPULAR REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
ÉCOLE NATIONALE POLYTECHNIQUE



المدرسة الوطنية المتعددة التقنيات
Ecole Nationale Polytechnique

Department of Chemical Engineering

End-of-Studies Project Dissertation

For the conferral of the State Engineering Diploma in Chemical Engineering

Modeling and Simulation of Hydrogen Production Processes Using
Aspen Plus

Ibrahim Elkhail FERROUDJ

Supervised by **Pr. SELATNIA Ammar** ENP

Publicly presented and defended on (23/06/2025)

Examination Committee Members:

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Examiner: Pr. Yacine KERCHICH ENP

ENP 2025

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Ecole Nationale Polytechnique

Département de Génie chimique

Mémoire de projet de fin d'études

Pour l'obtention du diplôme d'ingénieur d'état en Génie chimique

Modélisation et simulation des procédés de production d'hydrogen en
utilisant aspen plus

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Sous la direction de **Pr. SELATNIA Ammar** ENP

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ملخص :

تتناول هذه الأطروحة الحاجة الماسة لحلول الطاقة المستدامة، باستكشاف طرق إنتاج الهيدروجين والغاز التخليقي. لمواجهة تَقْطَع الطاقة المتجددة وتأثير الوقود الأحفوري البيئي، تركز الدراسة على نمذجة وتحليل مقارن للتقنيات الرئيسية: خلايا التحليل الكهربائي بأكسيد الصلب والقلوية، غشاء تبادل البروتون، وإصلاح الميثان بالبخار، و تغويز الكتلة الحيوية. باستخدام، طُورت ونُفذت نماذج ديناميكية حرارية وحركية مفصلة. تُقيم الأبحاث كفاءة الطاقة، واستخدام الكربون، والجدوى الاقتصادية، والأثر البيئي لهذه العمليات. تبرز النتائج الأولية إمكانات الأنظمة المتكاملة لزيادة الكفاءة وتقليل انبعاثات ثاني أكسيد الكربون، مما يساهم في تطوير استراتيجيات قوية ومستدامة لتحويل وتخزين الطاقة.

الكلمات المفتاحية : إنتاج الهيدروجين، الغاز التخليقي، التحليل الكهربائي، إصلاح الميثان بالبخار، تغويز الكتلة الحيوية، أسبن بلس، كفاءة الطاقة، استخدام الكربون، الجدوى الاقتصادية.

Résumé

Cette thèse aborde l'impératif des solutions énergétiques durables en examinant diverses méthodes de production d'hydrogène et de syngaz. Face à l'intermittence des énergies renouvelables et aux impacts environnementaux des combustibles fossiles, l'étude modélise et compare les technologies clés : électrolyse à oxyde solide (SOEC), électrolyse alcaline (AEC), électrolyse à membrane échangeuse de protons (PEM), reformage à la vapeur de méthane (MSR) et gazéification de la biomasse. Grâce à Aspen Plus, des modèles thermodynamiques et cinétiques détaillés ont été développés et validés. La recherche évalue l'efficacité énergétique, l'utilisation du carbone, la faisabilité économique et l'impact environnemental. Les résultats mettent en évidence le potentiel des systèmes intégrés pour optimiser l'efficacité et réduire les émissions de CO₂, favorisant des stratégies robustes de conversion et de stockage d'énergie.

Mots-clés : Production d'hydrogène, Syngaz, Électrolyse, SOEC, AEC, PEM, Reformage à la vapeur de méthane, Gazéification de la biomasse, Aspen Plus, Efficacité énergétique, Utilisation du carbone, Faisabilité économique.

Abstract

This thesis addresses the critical need for sustainable energy by exploring diverse hydrogen and syngas production methods. Confronting renewable energy intermittency and fossil fuel environmental impacts, the study models and comparatively analyzes Solid Oxide (SOEC), Alkaline (AEC), and Proton Exchange Membrane (PEM) Electrolysis, Methane Steam Reforming (MSR), and Biomass Gasification. Using Aspen Plus, detailed thermodynamic and kinetic models were developed and validated. The research assesses energy efficiency, carbon utilization, economic feasibility, and environmental impact. Findings underscore the potential of integrated systems to boost efficiency and cut CO₂ emissions, advancing robust and sustainable energy conversion and storage strategies.

Keywords: Hydrogen production, Syngas, Electrolysis, SOEC, AEC, PEM, Methane Steam Reforming, Biomass Gasification, Aspen Plus, Energy efficiency, Carbon utilization, Economic feasibility.

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Ibrahim Elkhail FERROUDJ.

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