Towards the Decarbonization of a Conventional Ammonia Plant by the Gradual Incorporation of Green Hydrogen

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I. Introduction & Motivation

- Ammonia (NH_3) is currently produced through the Haber-Bosch (HB) process, and its production accounts for **2 %** of the final energy consumed, nearly half of the hydrogen produced, and around **1-2 %** of the carbon dioxide emissions[1,2].
- **75 %** of NH_3 is produced from natural gas and naphtha, while the remaining **25 %** is produced from coal and Heavy Fuel Oil[1,2].
- In Europe, according to RED III, by 2030, **42 %** of the hydrogen consumed by industry must come from renewable sources.

II. Objectives

Understand the primary impacts of integrating green hydrogen into traditional ammonia synthesis processes. Building upon existing research[3], identify the operational and technological bottlenecks, and formulate a comprehensive decarbonization strategy for conventional ammonia production facilities.

III. Methodology

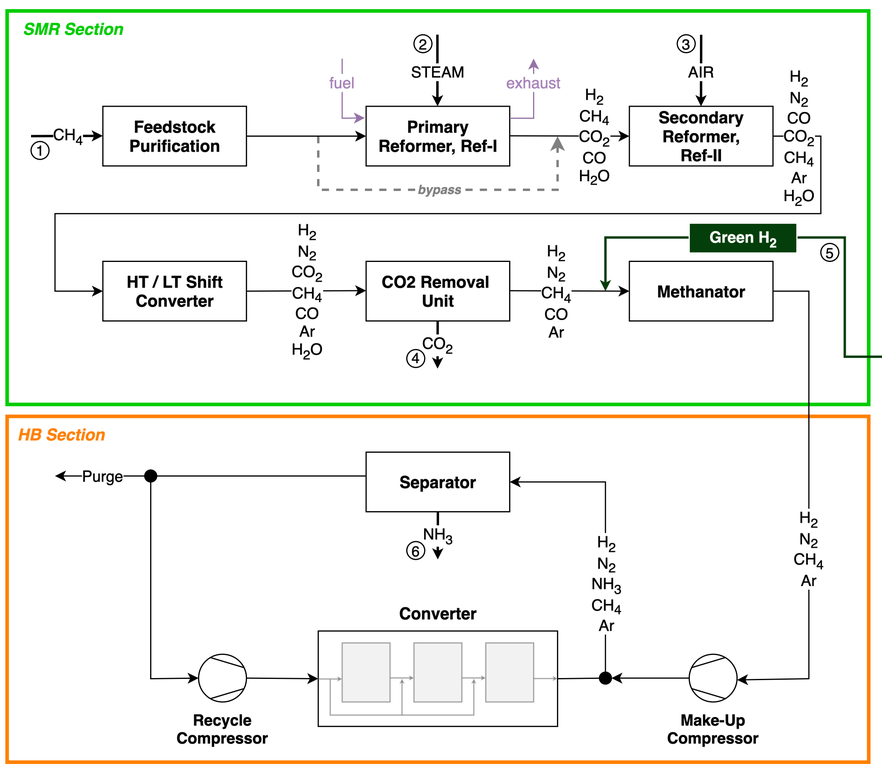


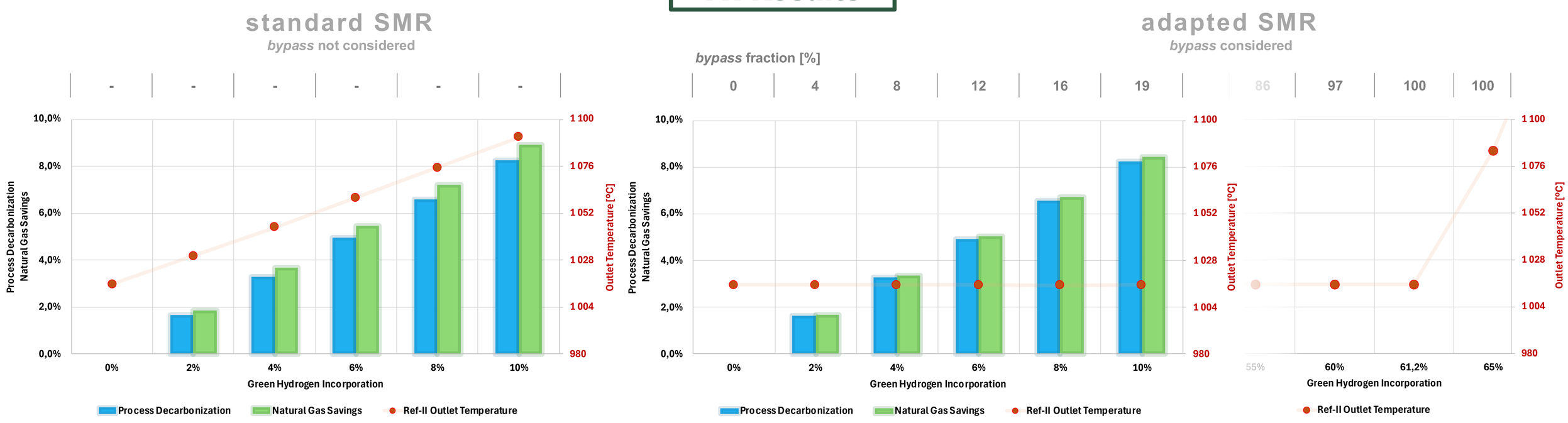
Figure 1. Simplified schematics of the model developed: SMR and HB sections.

- *Aspen Plus* ® modelling of the methane-fed NH_3 production process, divided into two sections: **SMR Section** (where hydrogen is produced by Steam Methane Reforming) and **HB Section** (where ammonia is synthesized through the reaction of hydrogen and nitrogen).
- The gradual decarbonization is achieved through the progressive integration of **green hydrogen** and the reduction of methane consumption, while maintaining ammonia production.

Green Hydrogen Incorporation | **Natural Gas Consumption** | **Ammonia Production**

- An adaptation to the SMR is proposed: a Ref-I bypass (Figure 1, - - -), to further address the limitations of green hydrogen integration and enhance the green hydrogen fraction and the extent of decarbonization.

IV. Results



V. Final Remarks

- The integration of green hydrogen leads to process decarbonization and enables natural gas savings.
- An increase in Ref-II outlet temperature is reported, which may cause equipment overheating and restrict further integration of green hydrogen.
- A Ref-I bypass helps prevent equipment overheating, enabling higher incorporations of green hydrogen (up to *c.* 60 %). It is an option to consider in a future decarbonization strategy for a conventional ammonia plant, along with other solutions to be proposed.

References:
[1] Rouwenhorst, K., Castellanos, G., International Renewable Energy Agency. & Ammonia Energy Association. Innovation Outlook: Renewable Ammonia
[2] IEA International Energy Agency. Ammonia Technology Roadmap - Towards More Sustainable Nitrogen Fertiliser Production. https://www.iea.org/reports/ammonia-technology-roadmap (2021)
[3] Isella, A., Ostuni, R. & Manca, D. Towards the decarbonization of ammonia synthesis – A techno-economic assessment of hybrid-green process alternatives. Chemical Engineering Journal 486, (2024)

Acknowledgments: Project co-financed by the PRR – Recovery and Resilience Plan by the European Union, in particular, the Mobilizing Agenda "Moving2Neutrality" (Project no. 32, with reference no. C644927397-00000038) and by the Fundação para a Ciência e a Tecnologia, I.P/; MCTES through national funds PIDDAC – CERENA (FCT-UIDB/04028/2025 and FCT-UIDP/04028/2025).