The faculty of Engineering of the Vrije Universiteit Brussel and the Graduate School of Maritime Sciences of the Kobe University invite you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES (VUB)
DOCTOR OF PHILOSOPHY IN ENGINEERING (KU)

of **Ander Martinez Alonso**

The public defense will take place on **Friday 1st August 2025 at 11 am** in room **D.2.01** (Building D, VUB Main Campus) https://maps.app.goo.gl/ENJ1QNVCqCNG1hWX6

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THE ROLE OF HYDROGEN IN SUSTAINABLE MULTI ENERGY SYSTEMS: AN OPTIMISATION FRAMEWORK FOR MULTI-CRITERIA ANALYSIS

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Abstract of the PhD research

The global energy transition is reshaping how we produce, transport, and consume energy, driven by the urgent need to address climate change and reduce dependence on fossil fuels. This shift is not only about producing clean electricity from sources like solar and wind, but about transforming the design and operation of the entire energy system to make it more decentralised, flexible, and resilient.

One of the most promising opportunities in this transition is renewable hydrogen, a clean energy carrier capable of storing energy long-term and at scale. Hydrogen can also strengthen connections between energy carriers, such as electricity and heat, and end uses like transport, industry, and feedstock production. However, using hydrogen sustainably is complex. Producing it requires significant energy, so its role must be carefully evaluated to ensure it is used where it adds the most value. Today, hydrogen is still produced from fossil fuels, which contributes significantly to global emissions. To truly support climate goals, hydrogen must be produced from renewable sources and integrated effectively into sustainable energy systems.

This PhD thesis develops a multidisciplinary framework to support that integration. It combines technical, economic, and environmental analysis with participatory decision-making tools, enabling a multi-criteria approach to the design and analysis of hydrogen-inclusive local energy systems. Through real-world case studies across the globe, the research demonstrates how hydrogen can contribute to affordable and deeply decarbonised energy solutions. By connecting science, society, and policy, this work supports more informed decisions for a cleaner, more democratic energy future, while critically assessing hydrogen's role as a piece of the broader energy transition puzzle.