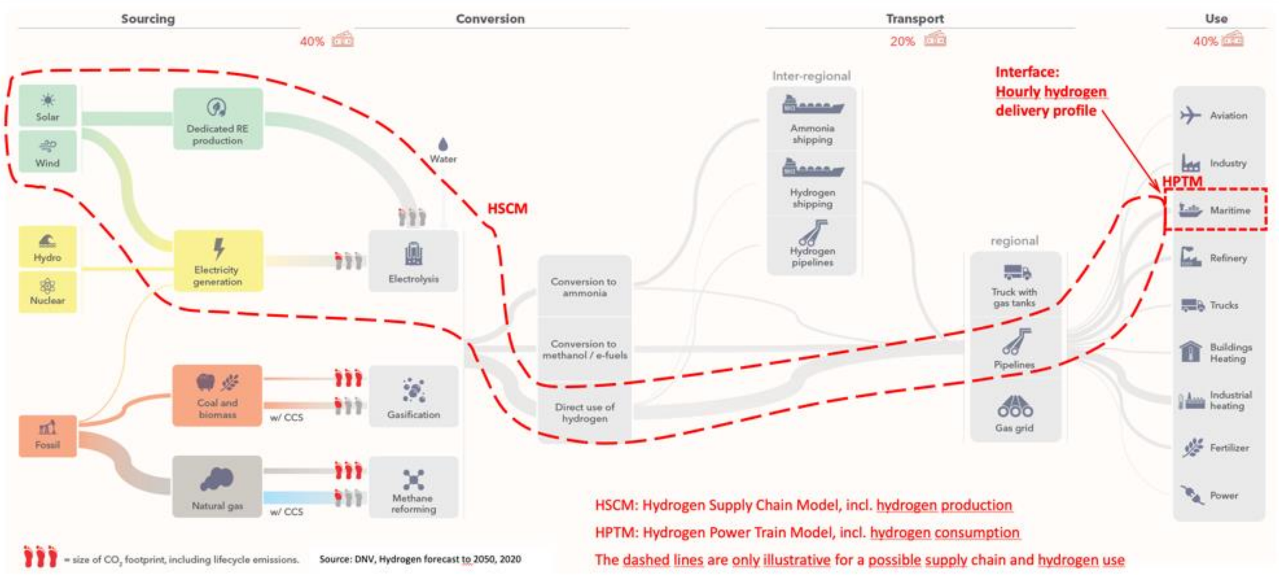
ENTRANCE
CENTRE OF EXPERTISE ENERGY

Hydrogen Systems Analysis and Optimisation- Multiple Master Thesis Projects

Client	ENTRANCE
Related project	Just Transition Fund – Hydrogen Train & Learn Hub
Start date	Flexible
Suitable for training course(s)	EMRE, SESyM, SSE, Operations Research, Physics, Mathematics, or similar
Learning Community	

Assignment context

We aim to model, analyse, design, and optimise hydrogen supply chains and hydrogen power trains for companies in the Northern Netherlands. The objective is an ENTRANCE hydrogen configurator, ENHyCo, developed in Python, which can be used to analyse companies' needs to switch from using fossil fuels to hydrogen. The chain covers green hydrogen from renewables to the conversion of hydrogen in applications. The latter vary from vehicles to industrial processes. An overview is schematically shown in the figure below. Although the focus is on technical feasibility and economic viability, i.e. minimising cost, the environmental impact is also considered. A first version of the configurator was developed, and multiple sub-studies were conducted. Optimisations were performed with the help of linear programming and heuristic methods. Models are validated with empirical data. However, continuous improvement and expansion, e.g. to other state-of-the-art hydrogen applications, addressing current practice-oriented problems, including uncertainties in supply and demand, are needed. Within this context, the student can define a thesis with us, corresponding to her/his interest.



Assignments

Examples of Master thesis topics (e.g., EMRE, SESyM, SSE, Physics, Operations Research, Mathematics) are presented below, but not limited to these (new original ideas are appreciated):

- Evaluation and comparison of currently developed optimisation models for hydrogen supply chains, notably Mixed Integer Linear Programming and Particle Swarm Optimisation, incl. convergence, accuracy, and calculation time. This was partly done, but must be elaborated in the Python environment, leading to a preferred optimisation approach. This may include one or more of the following issues: 1. Find optimal heuristic optimisation parameters to reach the optimal configuration values within a reasonable amount of time and with a reasonable accuracy. 2. Study, implement and compare different constraint handling strategies for meta-heuristic optimisation algorithms. See, for example, the paper by Rezaee Jordehi (A review on constraint handling strategies in particle swarm optimization, 2015). 3. Meta-heuristic optimisation algorithms work with floating point numbers. However, the number of wind turbines in the supply chain is an integer. How can integer optimisation be incorporated in meta-heuristic optimisation techniques? (for example: A. Fetanat, E. Khorasaninejad, Size optimization for hybrid photovoltaic-wind energy system using ant colony optimization for continuous domains based integer programming, 2025).
- How to define the lowest cost for different hydrogen applications? Can a common definition of lowest cost be used, and translated to different Total Cost of Ownership definitions for different applications? How can price forecasts be included?
- Control of a supply chain or power train: A start was made to model a variation on Model Predictive Control, with variation of forecasting period as one of the parameters. The content of this work must be further elaborated, the current code converted to Python, the applicability must be tested, and conclusions drawn. Potentially, this work can be followed by

an evaluation and comparison of control models (Load Following, Model Predictive Control, Fuzzy Logic)

- Integrating stochastic behaviour of supply (e.g. weather forecast) and demand, and their predictability in the development and implementation of optimisation and control models (e.g. Model Predictive Control). The state of charge of batteries at the beginning and end of a considered time must be included: should that be the same, or can it be (stochastically) varied? How would that influence the costs?
- Optimising electrolyser design. The balance of plant components around the stack and their configuration is slightly overlooked. Investigation of the additional components that make the stack operate and help to deliver hydrogen at the required pressure and quality. The produced raw hydrogen needs to be de-oxygenated (oxygen cross-over in the stack), dried and (possibly) compressed to the required application pressure. What is the optimal component size and process design when the electrolyser runs on intermittent renewable electricity? How could the heat management be optimised by better using the waste heat? What is the impact of a stack that operates at high pressure on the system costs?
- Influence of time-dependent component behaviour, e.g. degradation, change of efficiencies due to dynamic operation, hot-cold start, on system model behaviour. How should these parameters be included in an optimisation model, e.g. what time resolution should be used to enable including degradation, and how sensitive is a hydrogen system to such parameters? Should distinction be made between electrolysers, fuel cells, and batteries?
- For mobility applications: evaluation of the appropriateness of using different drive cycles, selection of applicable ones, and mutually compare these with a power train optimisation model (existing or adapted). The power train model components need to be checked: appropriate modelling of electric motor, supercapacitor, and converters.

General information

Final Product	Working and validated models
Location	ENTRANCE, Zernikelaan 17, Groningen
Parties involved	Tbd, depending on the topic
Contact person	Corina Vogt: c.b.vogt@pl.hanze.nl
Supervision	Jan Bekkering (j.bekkering@pl.hanze.nl) or other research group members, depending on the selected topic

ENTRANCE
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Who are we and where can you find us?

ENTRANCE is a learning community, where students and professors from various programmes cooperate with researchers, companies, governments and civil society organisations to accelerate the energy transition. We do this at the following locations:

- Location Proeftuin, Zernikelaan 17, Groningen

- Location Energy Academy Europe, Nijenborgh 6, Groningen

What do we offer?

ENTRANCE offers a multidisciplinary and inspiring learning, working and research environment where you can develop the competencies needed to shape and accelerate the energy transition. There is room for collaboration with professors, researchers, lecturers and the professional field. In addition, you will be supervised by professionals who are part of the ENTRANCE learning community.

Contact us

Are you interested in the vacancy? Do you have questions or would you like to apply immediately?

- Jacqueline Joosse, Coordinator ENTRANCE Learning Communities.
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