Planning Green Hydrogen Production

Supply Chains Manufacturing

GHD is one of the world's leading professional service companies operating in the global markets of water, energy, resources, and transportation. They provide digital engineering services to private and public sector clients. One of their areas of expertise is green hydrogen supply chain simulation.

Green hydrogen is made from splitting water using electrolysis powered by renewable energy, thus avoiding carbon production. When mixed with nitrogen

To evaluate the feasibility of such projects from both the engineering and financial sides, GHD applies green hydrogen supply chain simulation. This helps them link engineering design scenarios directly to business values. Unlike spreadsheet modeling, dynamic simulation better captures the complexity and risks, visualizes processes, as well as accounts for the projects' economics. Simulation models allow executives to interact with digital replicas of the projects and make more intelligent decisions.

Problem

An Australian company needed to build a green hydrogen production plant and a supply chain that would be financially and technologically efficient. Instead of building static green hydrogen logistics models, they hired GHD, who used a combination of traditional engineering design and dynamic simulation to:

- Develop a hydrogen production facility design.
- Evaluate the economics of the project.
- Assess the project's possible risks.
- Optimize the return on investments.

GHD chose AnyLogic as a simulation tool for the following reasons:

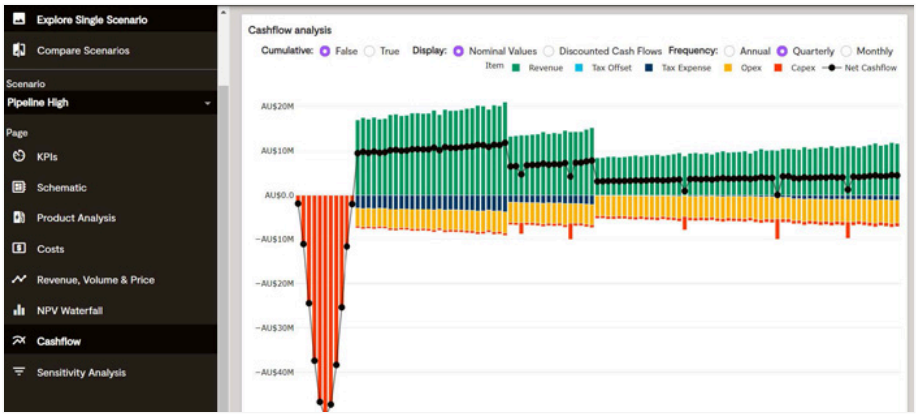
- AnyLogic allows for capturing the dynamics and variability. This was important because green hydrogen production, as all renewable energy, is variable and depends highly on the time of day and weather, as well as plant maintenance and asset

variability simulation opportunity.

- Extensive visualization capabilities make AnyLogic models more interactive and engaging for clients and stakeholders.
- AnyLogic model is not a “black box”. It is transparent, its inputs are separated from its logic, and in addition, AnyLogic provides model version control capabilities.

Solution

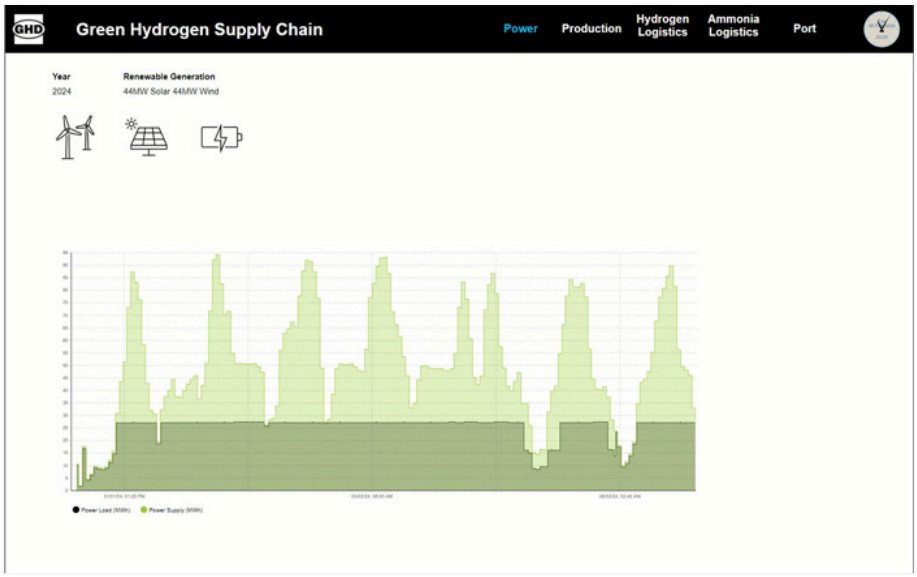
In the model, the production process takes raw inputs – desalinated water, air, and electricity – going to the electrolyzer plants, where different technology selections for hydrogen production are applied. Then, the hydrogen is compressed and goes to the ammonia plant where hydrogen is synthesized with nitrogen for easier transportation.



Cashflow analysis for the green hydrogen production supply chain (click to enlarge)

The precise simulation of gas production and storage was possible thanks to the AnyLogic Fluid Library. It

The viable options for hydrogen and ammonia logistics were also simulated, including modes of transportation and cost per km/kg, required assets, and enabling infrastructure. The cost of enabling port infrastructure to export ammonia was also considered.



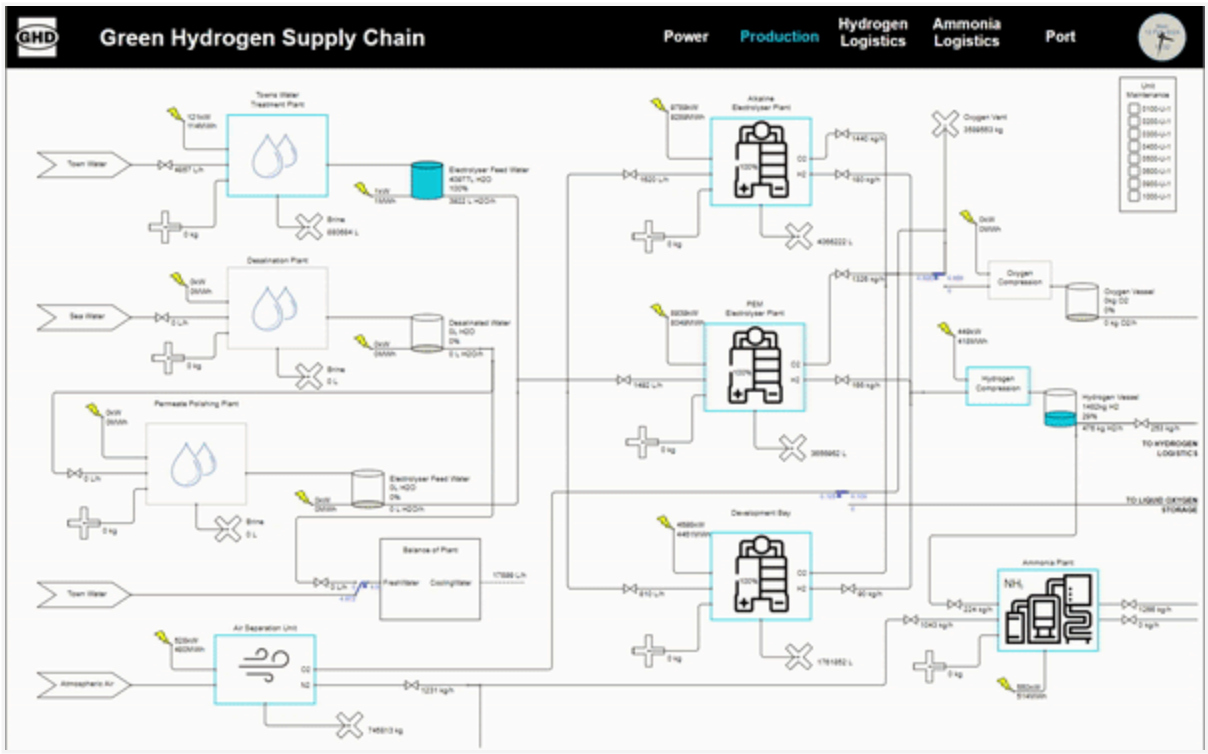
Power load and power supply in the green hydrogen supply chain (click to enlarge)

To post-process the outputs and provide detailed cashflow analysis, the Python integration capabilities of AnyLogic were used. They extended the green hydrogen supply chain simulation with the financial model which included statistics for cashflows, NPVs, levelized costs, ROIs, and other financial metrics. They visualized the analytics using dashboards so that the management could compare scenarios and look at the value changes over time.

The production and transportation green hydrogen model allowed the engineers to:

maintenance and breakages, influenced the green hydrogen lifecycle.

- See how much energy was being consumed at each production step to keep the plant operating and evaluate excess energy.



Green hydrogen supply chain model - a breakdown

Result

The green hydrogen supply chain model was used to:

- Assess trade-offs between renewable energy generation cost and production plant utilization.
- Compare market pathways of those who are buying the hydrogen.
- Find the optimal transportation method of product

The supply chain model combined different workstreams and allowed users to see how each stream affected the green hydrogen end-to-end lifecycle and different parts of the supply chain. It helped link engineering scenarios to business outcomes, which resulted in better planning and enterprise decision management. The simulation also brought more clarity into the interconnected processes, as well as captured uncertainty and variability, which is impossible with static models.

Although production of hydrogen at the needed cost is currently beyond reach, possible pathways to this goal were found. And the model assumptions can easily be updated as new information becomes available and costs reduce over time.

This case study is from a presentation given by Geoff Martin, Technical Lead of Simulation Analytics & Strategic Insights team, at the AnyLogic Conference 2021:

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