

Green chemicals

# Concept development for green hydrogen & chemicals



thyssenkrupp



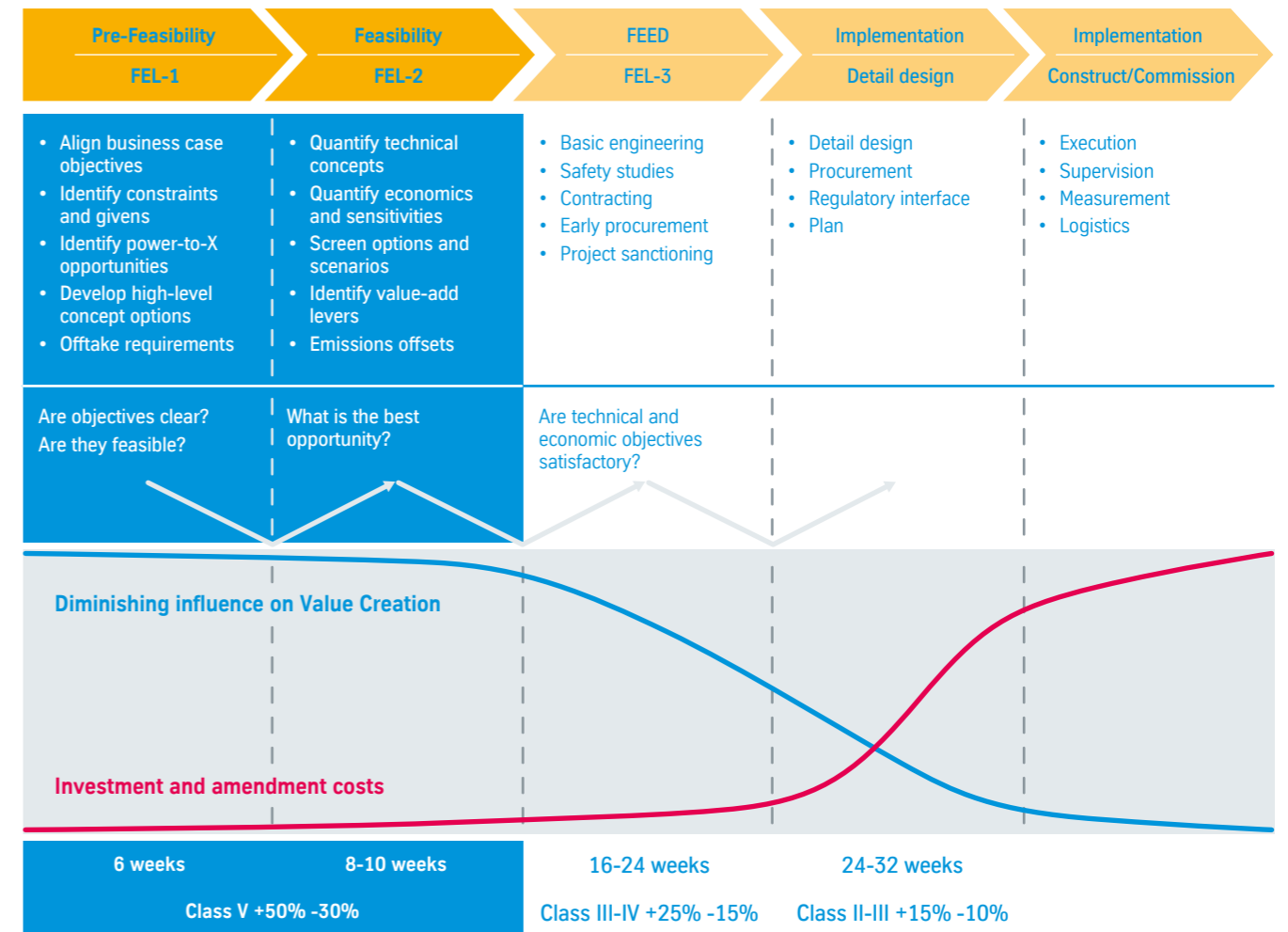


# Build your business case on know-how and experience

The biggest impact on total project value is at the early stages. This is true as much for green hydrogen and chemicals as for all large-scale projects. With decades of experience in the field, we can help you get the most out of your investment – right from the start.

The key question in any project development process is the economic viability of the project. Especially at the early stages of concept development, many decisions have to be taken which later have a huge impact on CAPEX and OPEX as well as on project execution. To best understand these aspects, techno-economic studies are used to investigate and evaluate hydrogen value chains and select the most appropriate concept. The aim is to identify the best opportunity for the lowest cost and to avoid late concept changes which incur costly rework as well as schedule delays.

## One technology, maximized feedstock flexibility



### What thyssenkrupp can do for you:

- Identify the most attractive hydrogen value chain concepts and/or derivatives
- Develop strategies for energy monetization
- Identify risks and opportunities
- Assist in engagement with potential partners and financiers
- Develop ideas sufficiently to estimate capital cost and quantify preliminary economics
- Develop the selected concepts in sufficient detail to obtain funding
- Develop a project road map

# thyssenkrupp's concept harmonization approach – the key to hydrogen value realization

The renewables-based production of hydrogen and its derivatives poses unique techno-economic challenges from determination of the ideal power generation mix (e.g. wind/solar ratio) and electrolysis operation to hydrogen storage optimization and intermittency management of the downstream processes.

You can leverage thyssenkrupp's know-how from nearly 100 years of experience in both electrolysis and chemical plant technologies, such as ammonia, methanol, SNG and fertilizers, on the scale required for the hydrogen industry. Plus we deliver technology and EPC project execution from a single source.

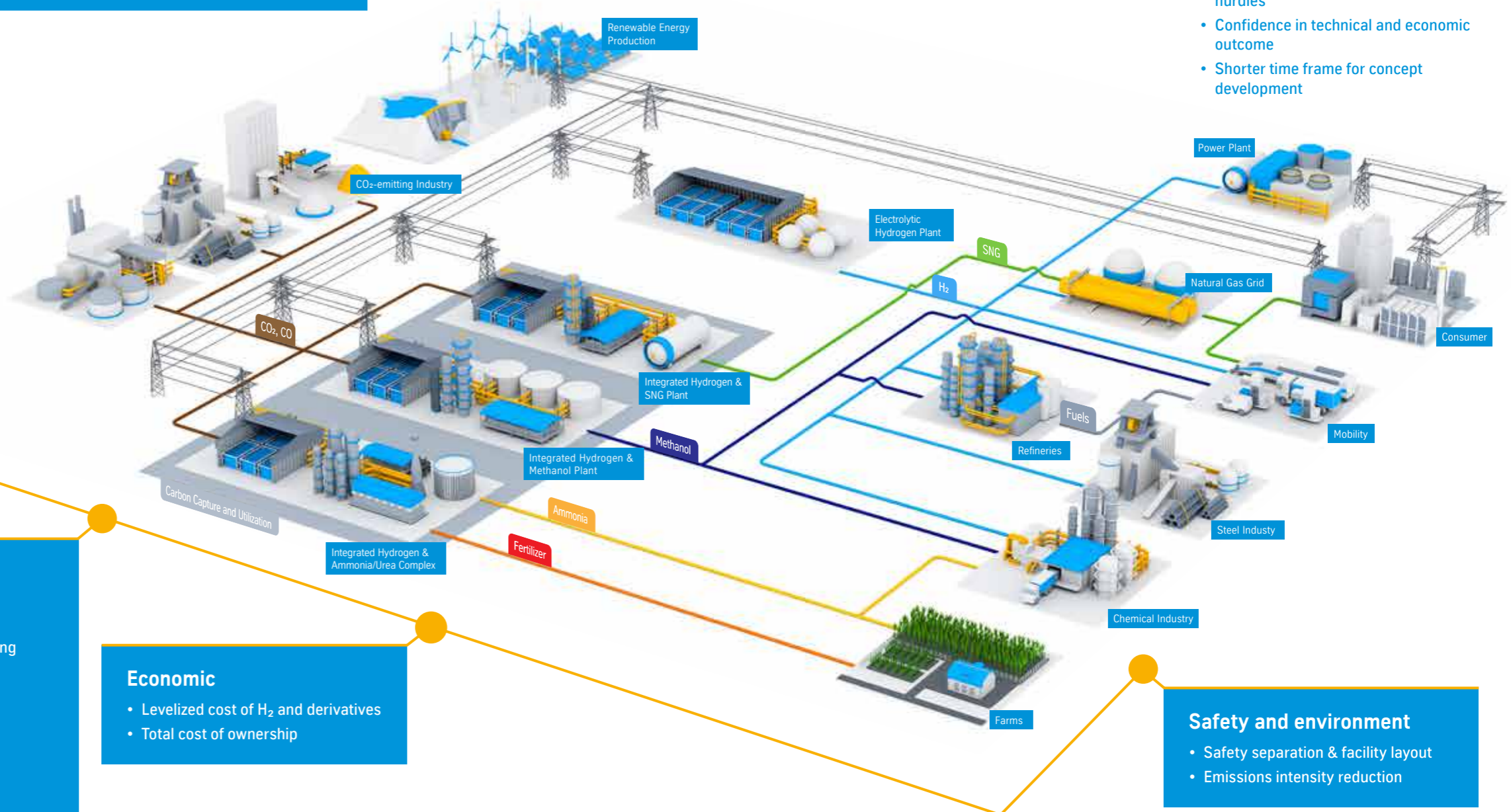
With decades of experience across the hydrogen value chain, we have developed a truly "end-to-end" optimization philosophy for green hydrogen concepts. Fully integrated plant concepts harness synergies, enable high-efficiency production and help to provide a reliable basis for your investment decisions – your key to overcoming any economic hurdles.

## Our proprietary know-how is a critical enabler for effective integration

Our proprietary know-how, developed over nearly a century in the industry, enables us to leverage the features of our technologies to deliver safe, efficient and environmentally sustainable concepts with the lowest total cost of ownership (TCO).

### Holistic solutions from a one-stop shop

- Seamless technology and performance handshake
- Superior concepts built on proprietary know-how
- Customized solutions to remove hurdles
- Confidence in technical and economic outcome
- Shorter time frame for concept development



### thyssenkrupp's integration approach

#### Concept harmonization

- Energy storage modeling (in front of & behind the meter)
- Optimization of electrolysis utilization depending on the application
- H<sub>2</sub> storage optimization
- Flexibility and efficiency enhancement
- Intermittency management
- Synchronization with energy storage and P2P elements (battery and fuel cells)

#### Economic

- Levelized cost of H<sub>2</sub> and derivatives
- Total cost of ownership

#### Safety and environment

- Safety separation & facility layout
- Emissions intensity reduction

# Finding the sweet spot for your investment: Concept modeling and optimization

Our techno-economic modeling tool RHAMFS<sup>®</sup> models hydrogen and chemical production in real time

RHAMFS<sup>®</sup> has been specifically developed for holistic performance modeling across the whole green hydrogen value chain, right from power feed characterization to product dispatch. Based on our decades of technical and economic data, it can perform dynamic and multivariable modeling to determine the most practical and cost economic concept for any power-to-X application, be it greenfield or brownfield.

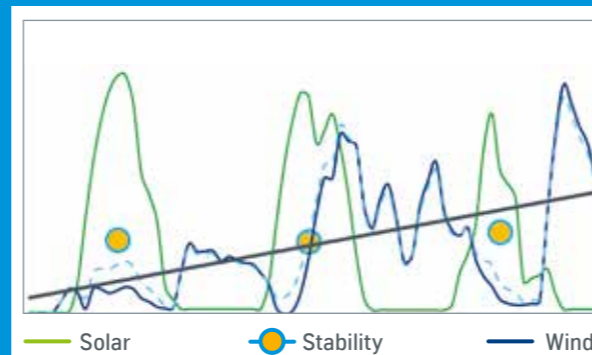
Our technical configuration models are matched with equally robust economic evaluation modules based on market-tested cost metrics. As a result, multiple concept configurations can be efficiently and iteratively tested for economic viability.

## The key features of RHAMFS<sup>®</sup> include:

- Economic modeling of centralized as well as distributed hydrogen and chemical facilities
- Real-time modeling of electrolyzer utilization and production (H<sub>2</sub> and derivatives)
- Chemical export value chain modeling
- Hydrogen storage optimization
- Sector coupling assessment
- Total cost of ownership
- Estimation of carbon emission offset

### Renewable power stability analysis

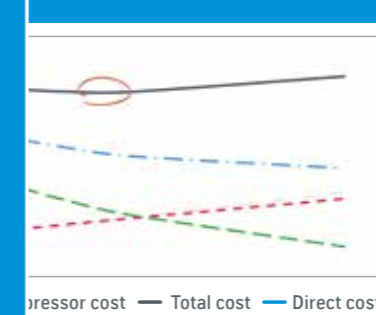
Renewable energy mix optimization



### Green hydrogen & chemical production modeling



### Hydrogen storage optimization

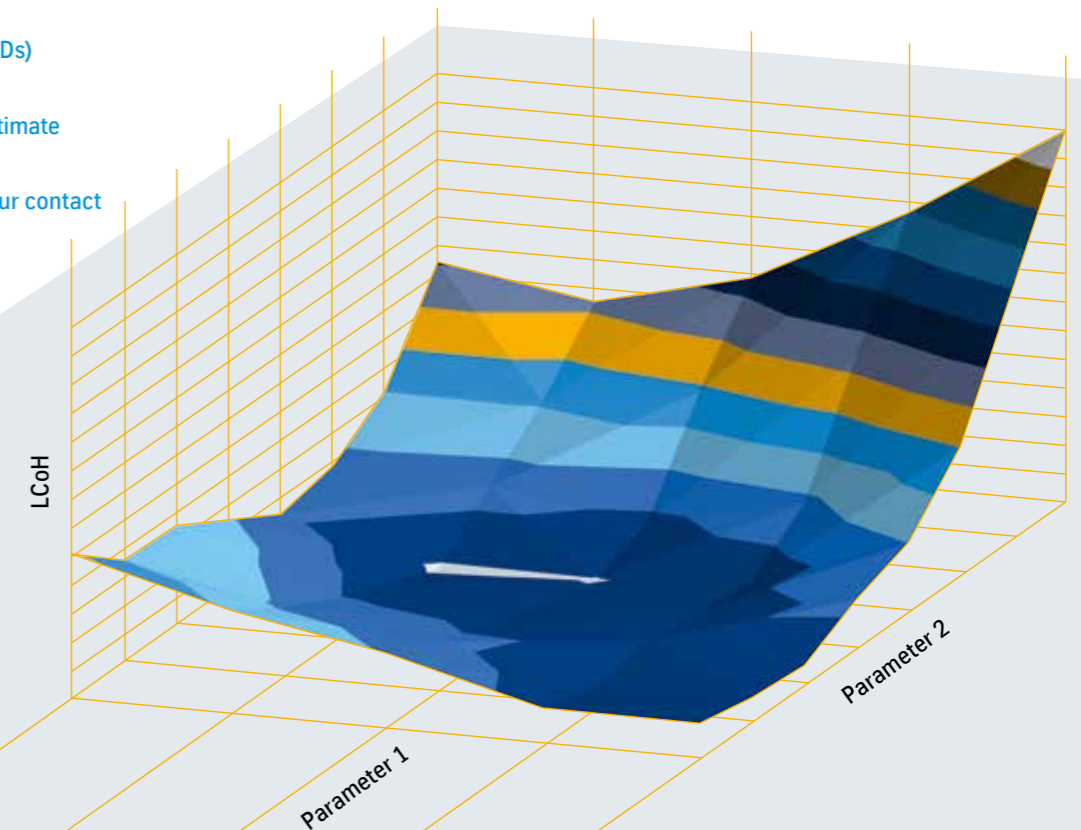


- Storage pressure cycling assessment
- Dynamic electrolyzer and chemical production modeling
- Intermittency assessment for flexibility enhancement
- Grid balancing revenue assessment

## What you can expect from our concept study reports:

- Techno-economically optimized end-to-end concept for export or domestic use
- Green hydrogen and derivative chemicals product slate assessment
- Sector coupling options
- Risk and opportunity realization
- Consumption summary
- Block flow diagrams (BFDs)
- Facility layout
- AACE Class IV-V cost estimate
- Execution schedule

Interested? You will find our contact details on the next page.



## Chemical and Process Technologies

thyssenkrupp Green Hydrogen & Chemicals – Engineering and Technology  
Level 4, 99 King Street  
Melbourne, Victoria 3000  
Australia  
[GreenHydrogen-IS-Australia@thyssenkrupp.com](mailto:GreenHydrogen-IS-Australia@thyssenkrupp.com)  
[www.thyssenkrupp-industrial-solutions.com/power-to-x](http://www.thyssenkrupp-industrial-solutions.com/power-to-x)

thyssenkrupp Uhde Chlorine Engineers  
Voßkuhle 38  
44141 Dortmund  
Germany  
[water.electrolysis@thyssenkrupp.com](mailto:water.electrolysis@thyssenkrupp.com)  
[www.thyssenkrupp-industrial-solutions.com/power-to-x](http://www.thyssenkrupp-industrial-solutions.com/power-to-x)