



Introduction to REFHYNE Project: 10MW Electrolyser at the Rhineland Refinery

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Hiroki Hirai

Business Development Manager, Shell Japan Ltd.

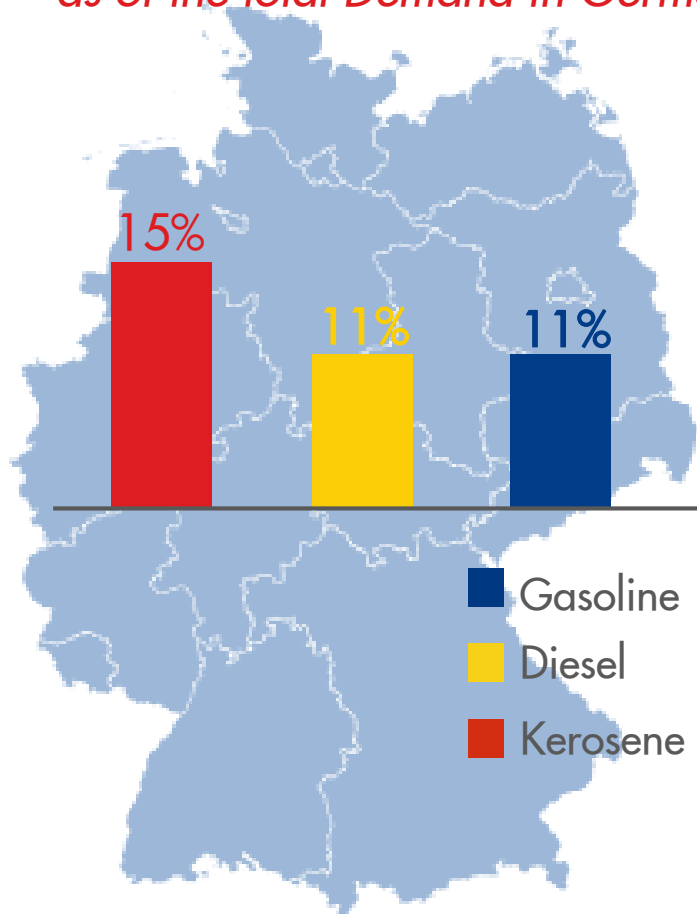
Shell Rheinland Refinery – Major Energy Supply Hub

- Crude Oil throughput of more than 17 million tons per year (largest refinery in Germany)
 - Crude arrives via pipeline from Rotterdam and Wilhelmshaven
- Supply Channels:
 - 34 percent via ship and own harbours
 - 28 percent via road
 - 22 percent via pipelines
 - 11 percent via pipelines to neighbour industries
 - 5 percent via rail



Portrait of the Shell Rheinland Refinery

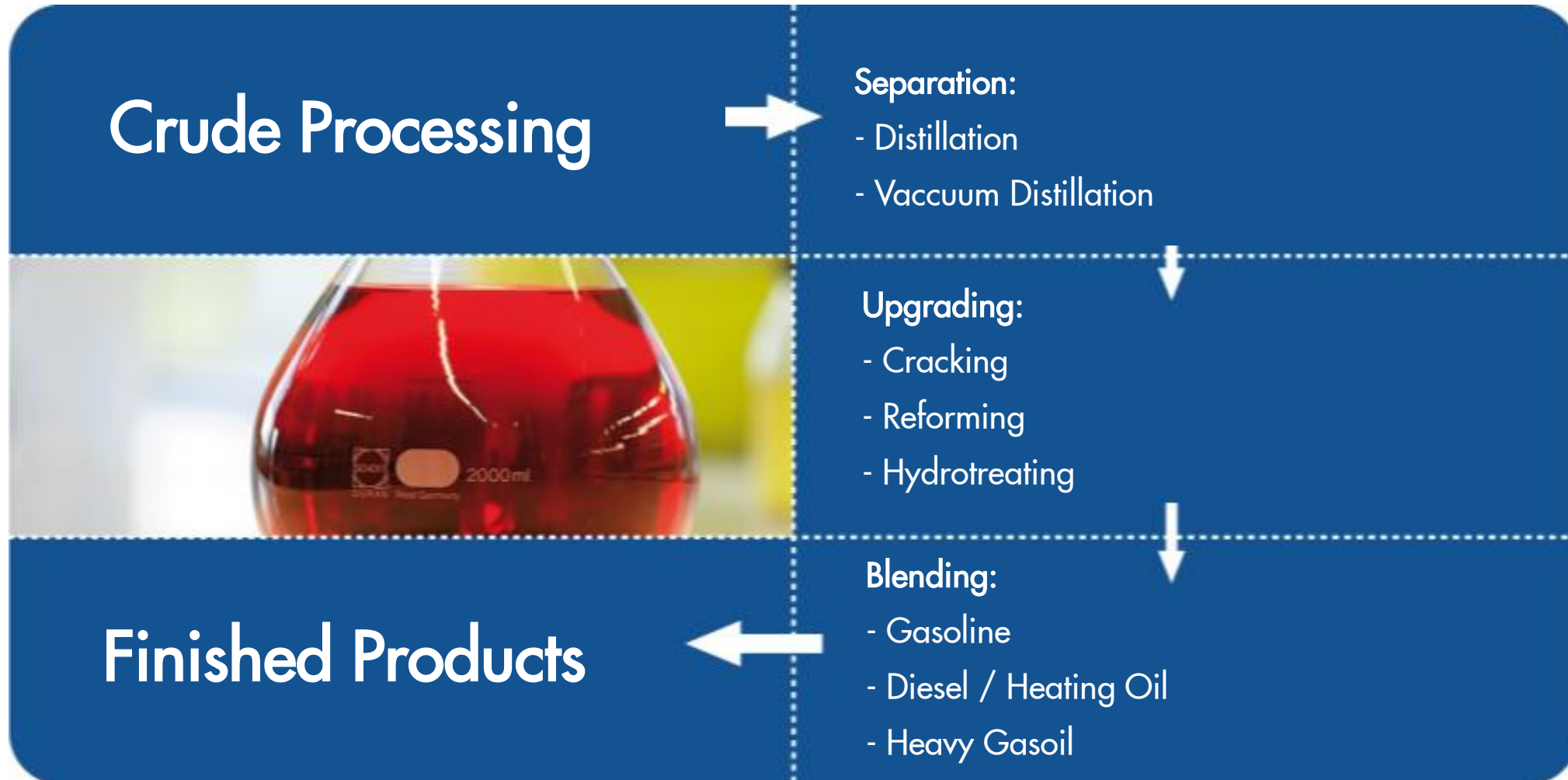
*Percentage of the Rhineland Refinery Supply
as of the total Demand in Germany*



Products of the Rheinland Refinery (Wesseling Site & Godorf Site) :

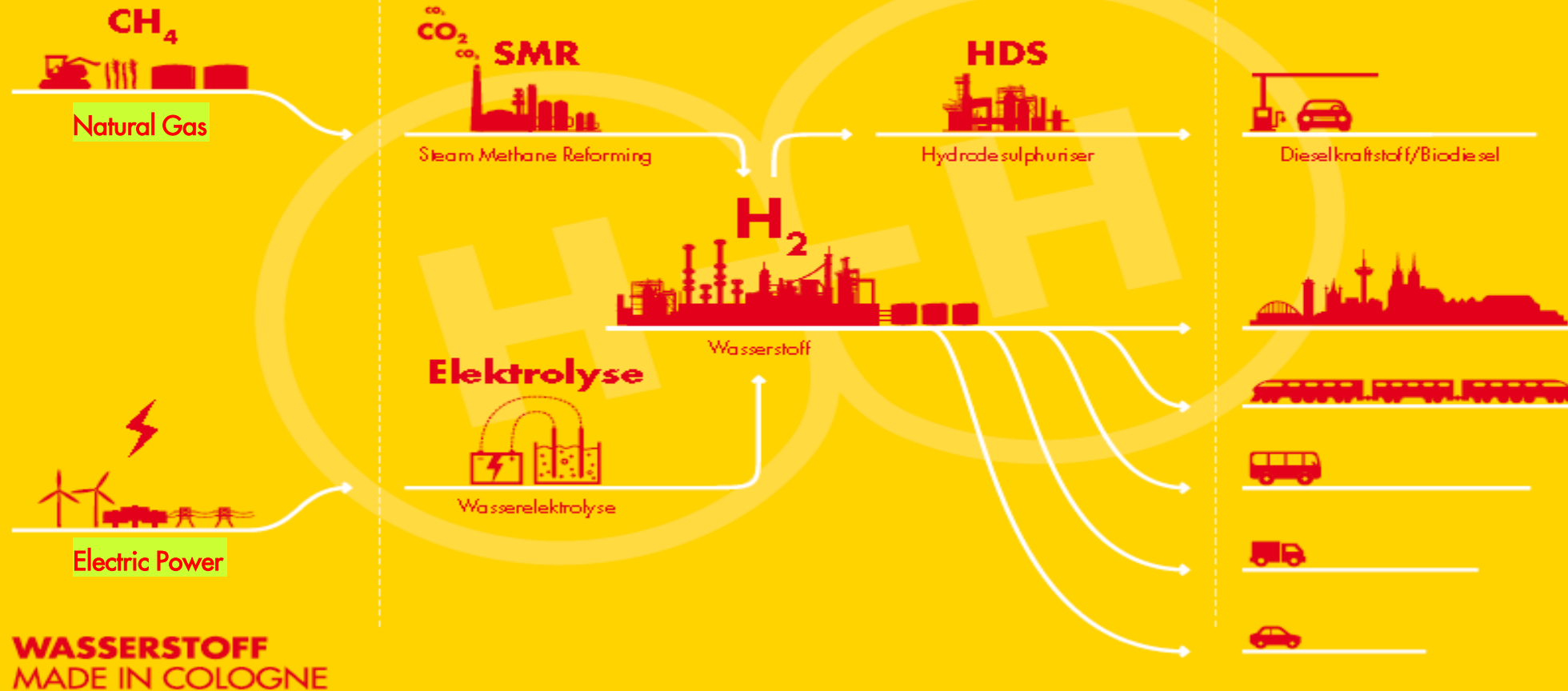
- Heating Oil / IGO: 2,4 mln tons/a
- Jet Fuel: 1,4 mln tons/a
- Diesel / AGO: 5 mln tons /a
- Gasoline: 2,3 mln tons/a
- Aromates: 1,5 mln tons/a (about 83,5% of the total demand in Germany)
- Chemical Feedstock: 2,2 mln tons/a
- LPG: 0,1 mln tons/a
- Sulfur: 70.000 tons /a
- Ethylen, Propylen: 0,5 mln tons/a (only Wesseling Site)
- Residue (HVR, VR, IMF): 0,8 mln t/a
- Bitumen: 0,75 mln t/a (only Godorf Site)

Crude Processing



Hydrogen - Mobility - Made in NRW

RHEINLAND RAFFINERIE



Hydrogen Balance in the Rheinland Refinery

Total Hydrogen Demand of the Rheinland Refinery: **about 180,000 tons /a**

Used for:

- De-Sulphurisation (Gasoil, Naphtha)
- Cracking (Hydrocracker)

Produced by:

- Platformers (Mogas Upgrading)
- Steam Crackers
- Gasifiers
- Steam Methane Reformers (SMRs)

About 20-30% is produced through SMRs basde on natural gas:

=> this could be potentially replaced by hydrogen from electrolysers based on renewables

How the stars got aligned for the Electrolyser at the Rhineland Refinery

- **Shell Germany reflected on the ongoing Energy Transition in Germany**
 - Shell Energy Scenarios for Germany 2050 established in 2016/17
 - Cross-Business Idea Gathering in July 2016
 - Electrolyser identified as a potential opportunity

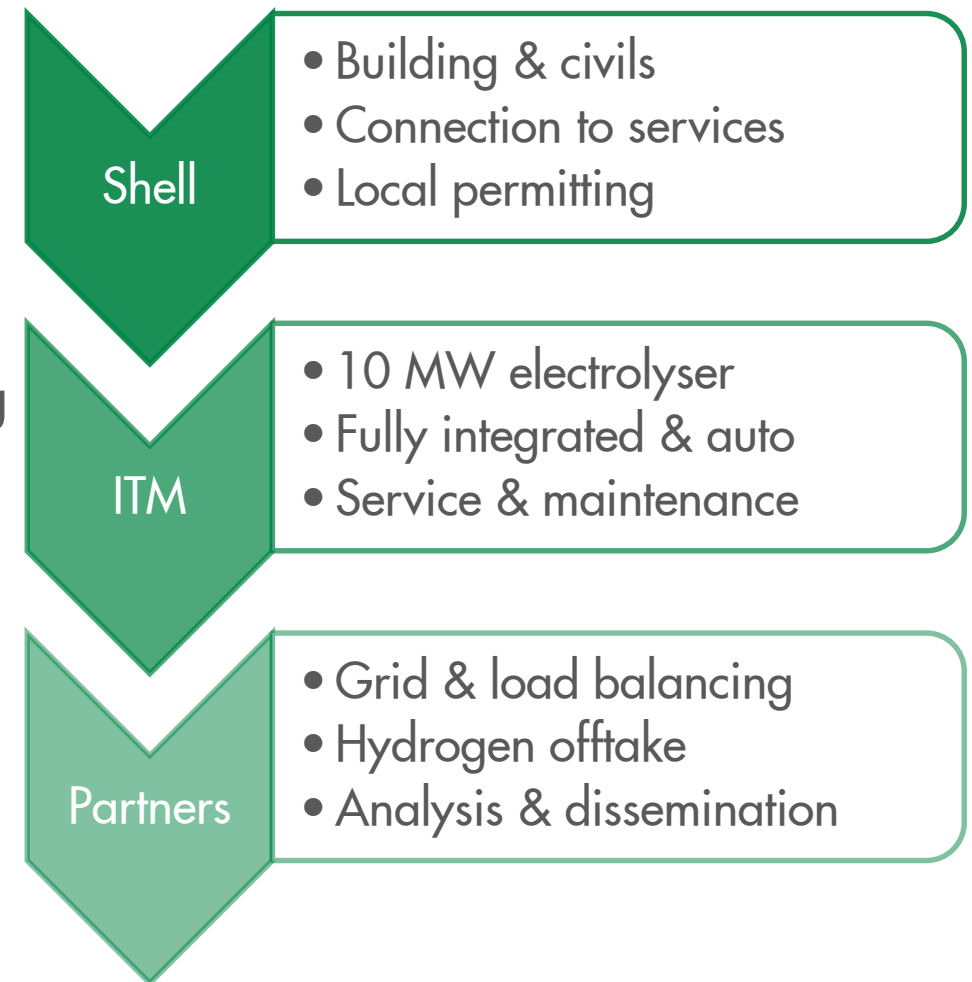
- **Building on the existing Shell / ITM Power co-operation in hydrogen**
 - Good track record for hydrogen in Germany
 - UK retail sites with small electrolysers
 - Positive experience with EU FCH JU funding

- **EU FCH JU Funding Round 2017 opened the door to enable it**
 - Fuel Cell & Hydrogen Joint Undertaking (FCH JU) annual tender process
 - Funding calls in various Fuel Cell / Hydrogen areas
 - One call in 2017 for a large 10 MW electrolyser

Project Overview – World Largest PEM Electrolyser

- Deployment of 10 MW PEM electrolyser
- On-site hydrogen & oxygen generation
- Hydrogen to be fed to existing hydrogen system
- Option to recover oxygen
- Flexible & rapid response electrical load
- Capable of site load balancing & wider grid balancing

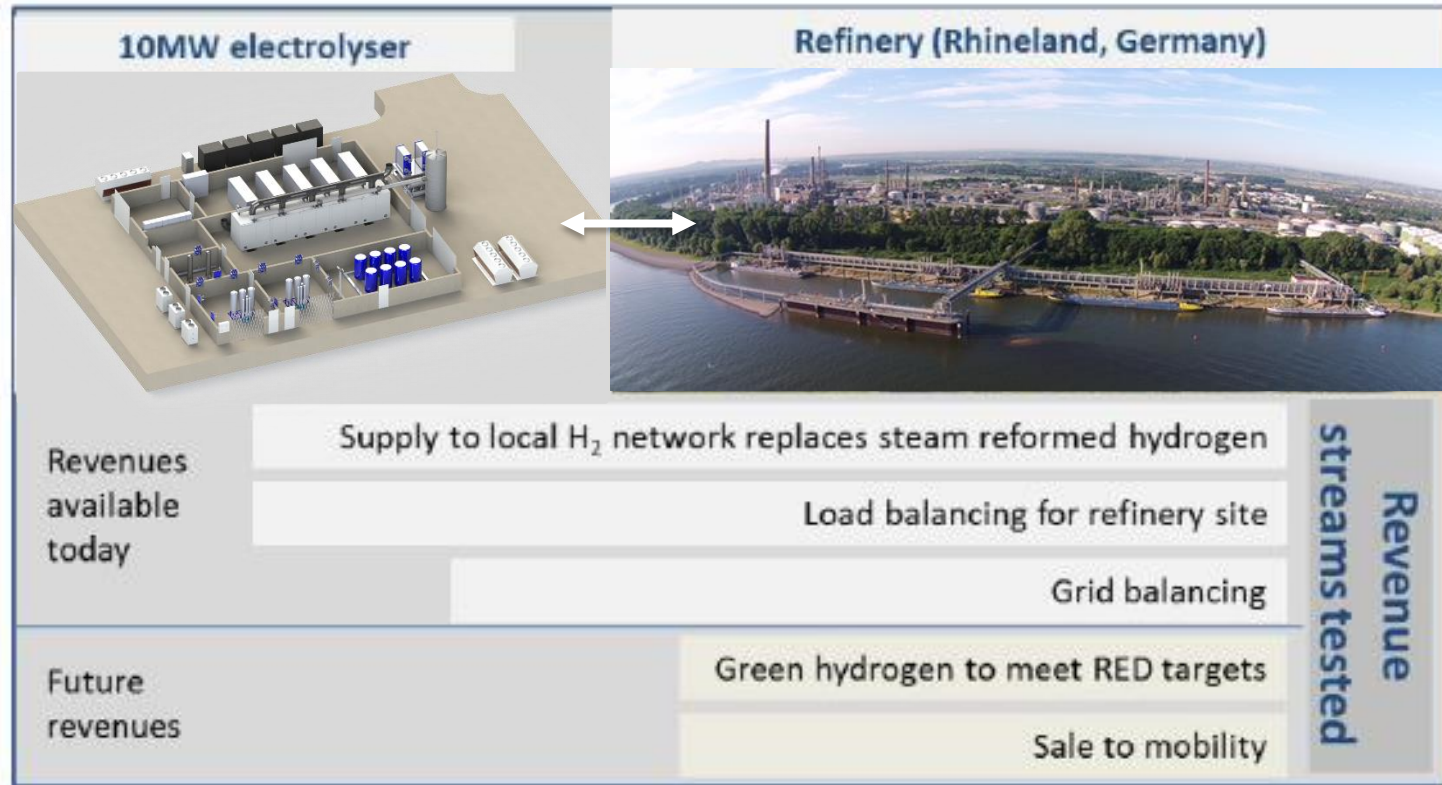
- ITM & Shell jointly developed a bid for EU funding
- Successful bid securing with ~60% funding
- Requirement to undertake certain test profiles
- 5 year project
- 2 years design, build & deploy
- 3 years test operation





thinkstep

elementenergy



Technical, economic and environmental performance assessed

Business models and policy implications disseminated widely

FORMAL KICK-OFF ON JAN. 18TH 2018: EUROPEAN CONSORTIUM WITH SHELL AND ITM POWER ANNOUNCE AGREEMENT TO BUILD ELECTROLYSIS AT RHINELAND REFINERY

Shell and ITM Power will build the world's largest hydrogen electrolysis plant at Rhineland refinery, Germany. With a peak capacity of 10 megawatts the hydrogen will be used for the processing and upgrading of products at the refinery's Wesseling site as well as testing the technology and exploring application in other sectors.

The European partner consortium of Shell, ITM Power, SINTEF, thinkstep and Element Energy has now secured 10 million euros in funding from the European "Fuel Cell Hydrogen Joint Undertaking". The project's total investment, including integration into the refinery, is approximately 20 million euros.

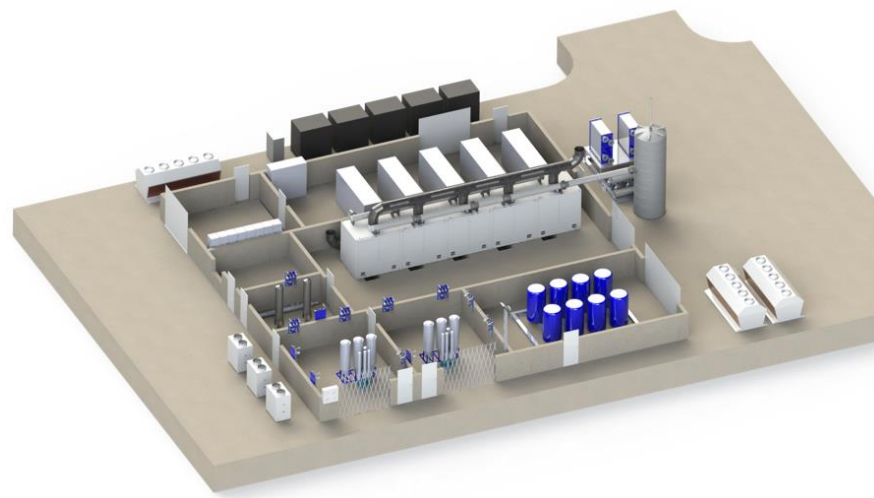
Detailed technical planning and the approval process will now begin. The plant, named "Refhyne" is scheduled to be in operation in 2020 and will be the first industrial scale test of the polymer electrolyte membrane technology process.



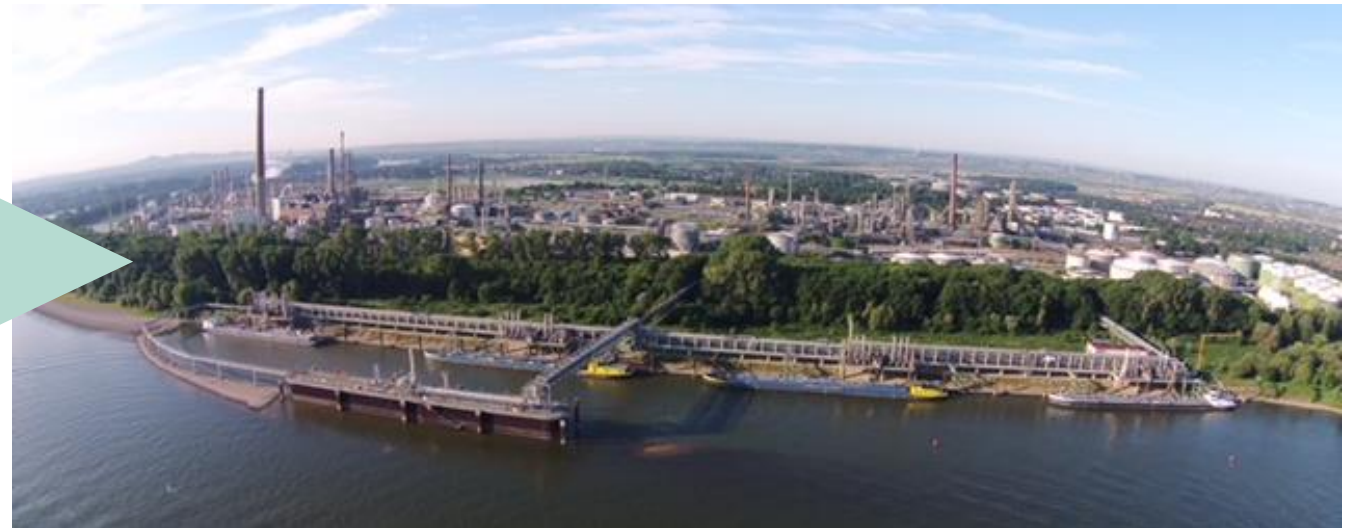
REFHYNE Objectives

- Assessing the economic, technical & environmental impact of the deployment of a large scale electrolyser
- Developing and testing business models based on existing & future revenue streams in a changing energy setting
- Exploring the policy implications of the technology and disseminating the project results across Europe

10 MW ITM Power Electrolyser



Rheinland Refinery (Wesseling, Germany)



Revenue streams

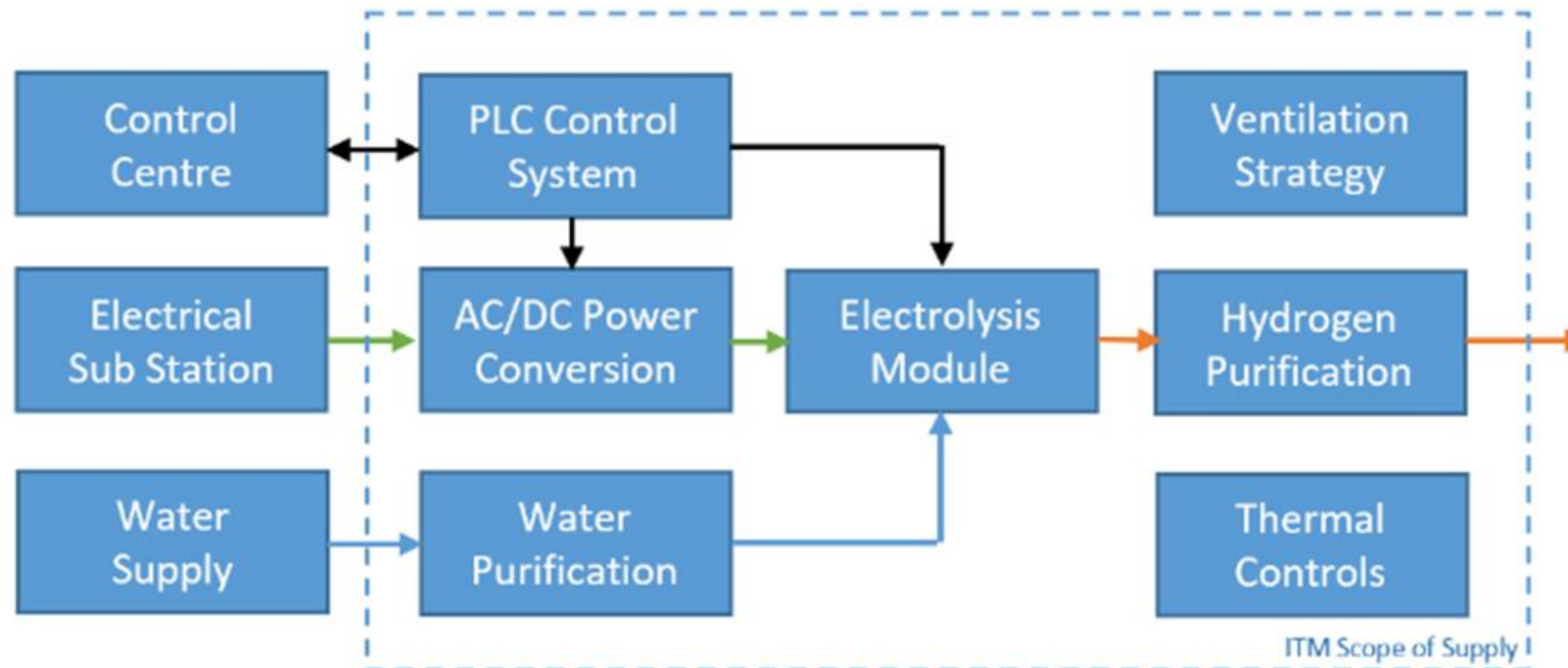
Supply to local gas network replacing steam reformed hydrogen

Load balancing for refinery site

Grid balancing

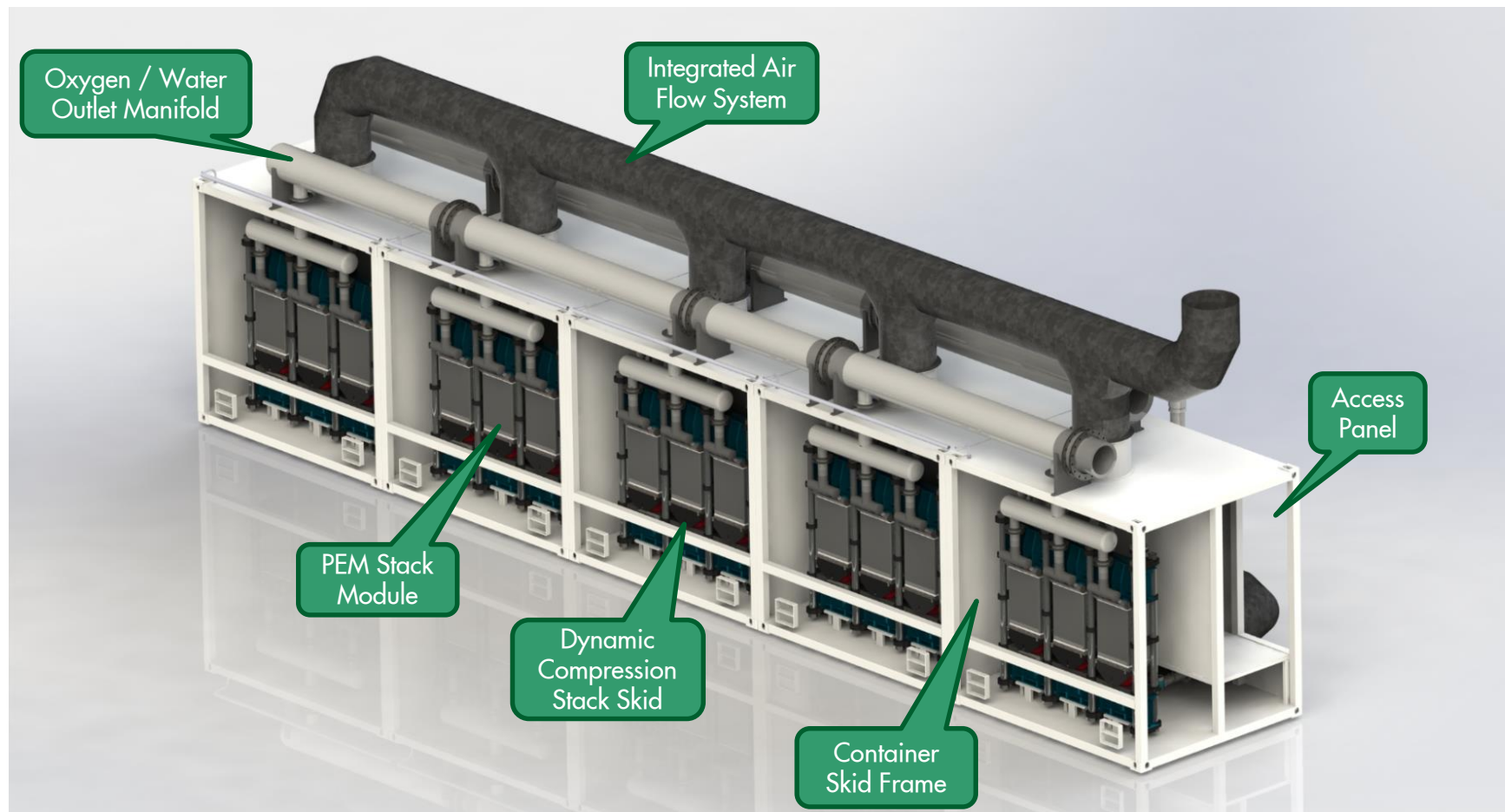
The electrolyser will enable large scale hydrogen production

- The traditional route for hydrogen production at large scales is Steam Methane Reformation (SMR), directly producing CO₂
- Electrolysers split water into oxygen & hydrogen using an electro-chemical reaction, and thus, when using low CO₂ electricity can reduce the emissions required to produce hydrogen
- ITM Power's electrolyser will be a fully integrated and autonomous system using a 10 MW stack skid
- At full load, the plant will be capable of generating 4 tonnes of hydrogen per day



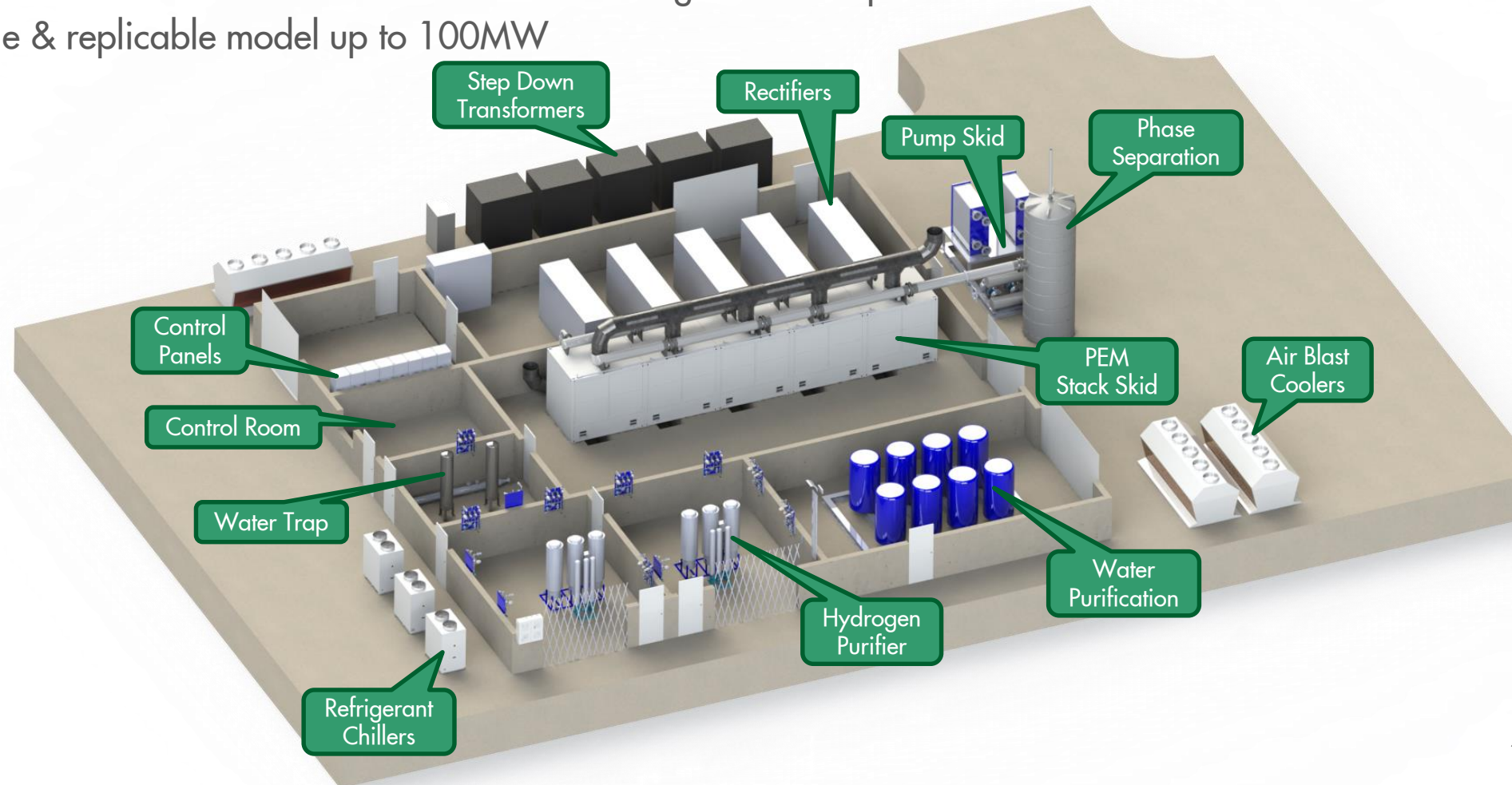
The 10 MW ITM Power Stack Skid

- The 10MW stack skid comprises 5x 2MW sub modules packaged into one unit
- Each sub module can be operated independently providing operational flexibility and resilience
- Well proven PEM technology enabling ultra-fast response - Stack efficiency will be between 45 and 55 kWhr/kg

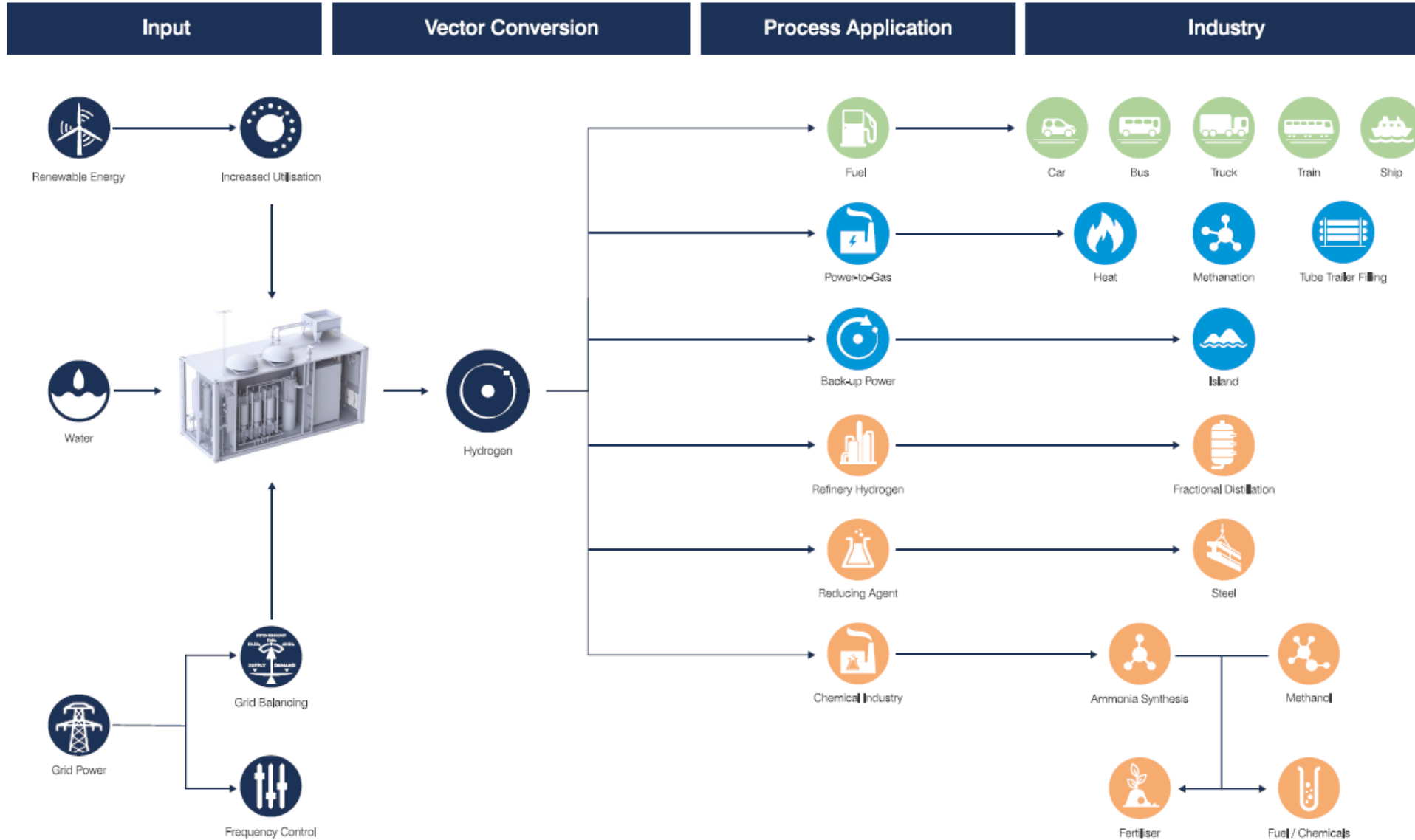


System Layout Concept

- The electrolyser system incorporates all necessary balance of plant from rectifiers to hydrogen purification
- The equipment will be located in a new, single storey building in the refinery - Building footprint approx. 25x25m
- Sub-systems will be located in different rooms according to AtEx requirements
- Expandable & replicable model up to 100MW



Many Options for Hydrogen from PEM Electrolysers



To enable green hydrogen in the future which regulatory framework is needed?

For 2030 the Renewable Energy Directive (RED II) is key to create value for green hydrogen in refineries:

- the **use of green hydrogen as an intermediate in refineries** to be used for compliance under RED II needs to be incentivized.
- the counting of green hydrogen as fully renewable should be possible **by sourcing renewable electricity from the grid** and not be limited to a direct connection of renewable electricity production.
- green hydrogen should be allowed to benefit from the provision to account electricity as 100% renewable if the plant has entered a long term **Power Purchase Agreement (PPA)** for renewable electricity as proposed by Parliament for renewable electricity.

Further, continued EU support post-2020 via the Fuels Cell Joint Undertaking should be enabled.

For 2050, the role of hydrogen as storage possibility for intermittent renewables and enabler for sector coupling needs to be further incentivized as part of the European Commission's 2050 Strategy.

Acknowledgement

COORDINATION



DEMONSTRATION



DATA ANALYSIS & DISSEMINATION



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