Green hydrogen benefits & global development with implications on Vietnam

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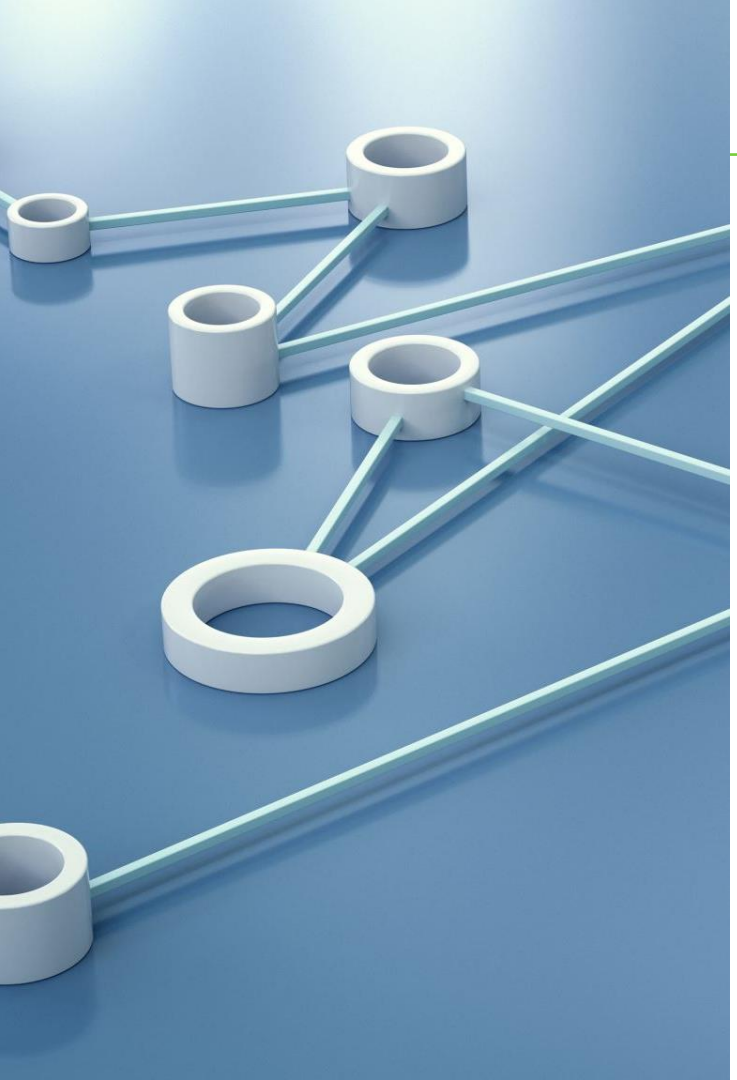
21 February 2023

Further information & contact: https://abl-group.com/renewable-energy-engineering-consultants/hydrogen/



Presentation Overview

- Overview of ABL Group & Hydrogen - ammonia offerings
- Economic benefits & challenges of hydrogen from renewables
- Challenges of power systems & Potential benefits of green hydrogen
- Global hydrogen development with implications on Vietnam
- Suggestions for green hydrogen industry development in Vietnam

ABL Group is a leading global independent energy and marine consultancy working in energy and oceans to de-risk and drive the energy transition across renewables, maritime and oil and gas sectors.

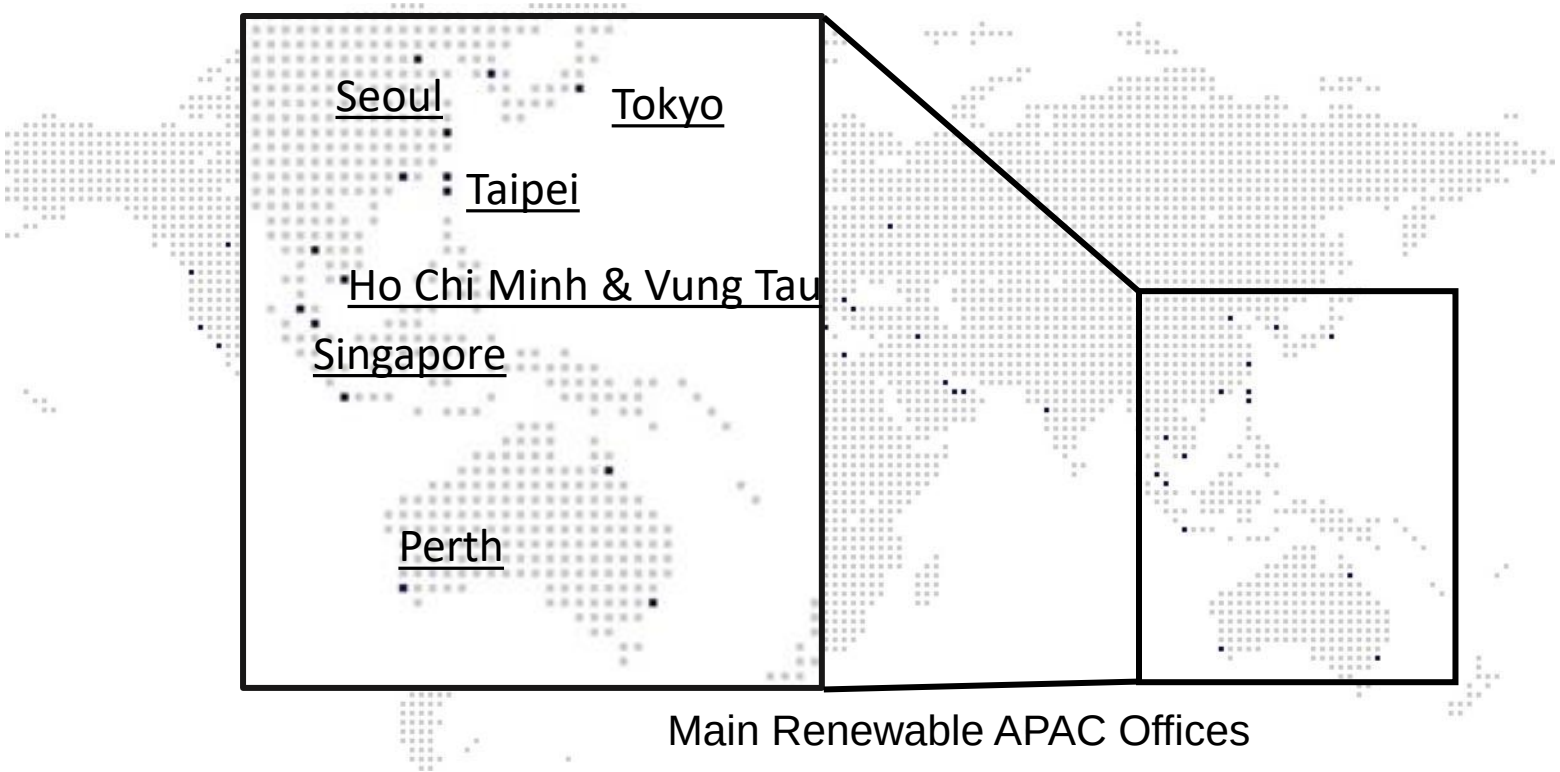
Global Partner, Local Expert

63
Offices

40+
Countries

303**
Locations

1120*
People



Main Renewable APAC Offices

* Includes subcontractors on 100% utilisation basis. Calculated as an average during Q2 2022.
** ABL locate many staff strategically at maritime and offshore hubs to be able to serve clients locally
Additional note: the 40 countries number is driven by our offices, in terms of locations where we have surveyors etc we cover 71 countries, a truly global footprint

ABL Group Hydrogen & Ammonia Offerings

OWC An ABL Group Company

Only one contact/entity needed (convenient for Clients)

LONGITUDE An ABL Group Company

- Hydrogen project development
- Technology/ cost/ markets advisory
- Green H2 production design
- Offshore/subsea storage systems
- Electrical for electrolyser BOP
- Integration with renewable plants
- Battery – electrolyser coupling (with ABL)
- Pipeline (with Longitude)
- Green ports (with Longitude)
- R&D

- Hydrogen / ammonia storage & transportation engineering & design
- Ship design, conversion and new build
- Hydrogen/ ammonia application design (e.g. maritime, ferries, ship)
- Electrical electrolyser/fuel cell

Planning & Design | **Build /Re-stack** | **Operations** | **Decommissioning**

Market research; FS

Business Plan/ Roadmap

Technology assessment

Consulting & Engineering; Due Diligence; R&D for innovative solutions/concepts

ABL Group experience: ~40+ projects over roadmaps, production, storage & transportation, and consumption/application

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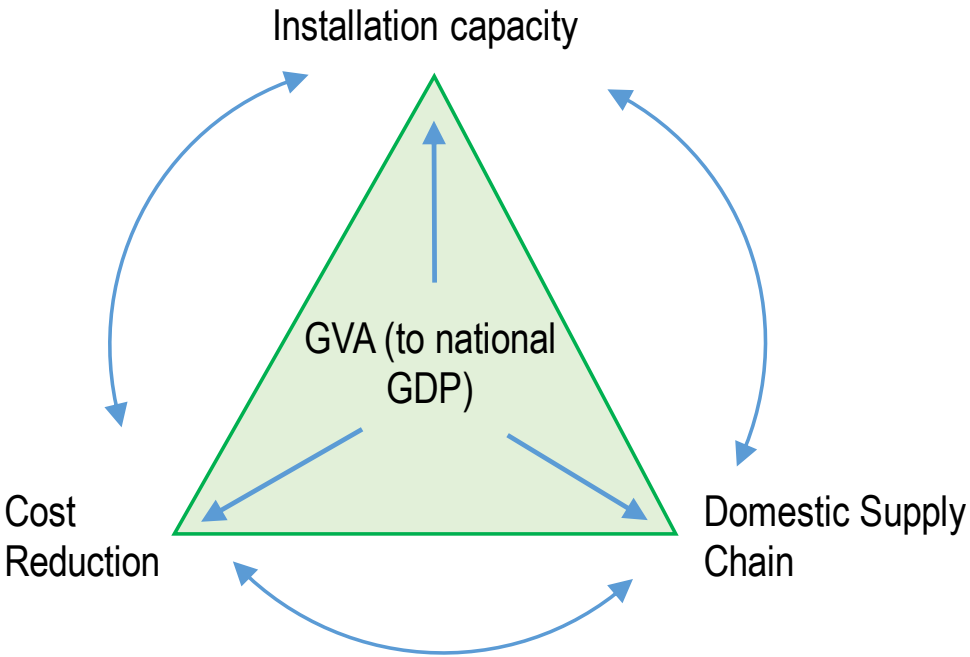
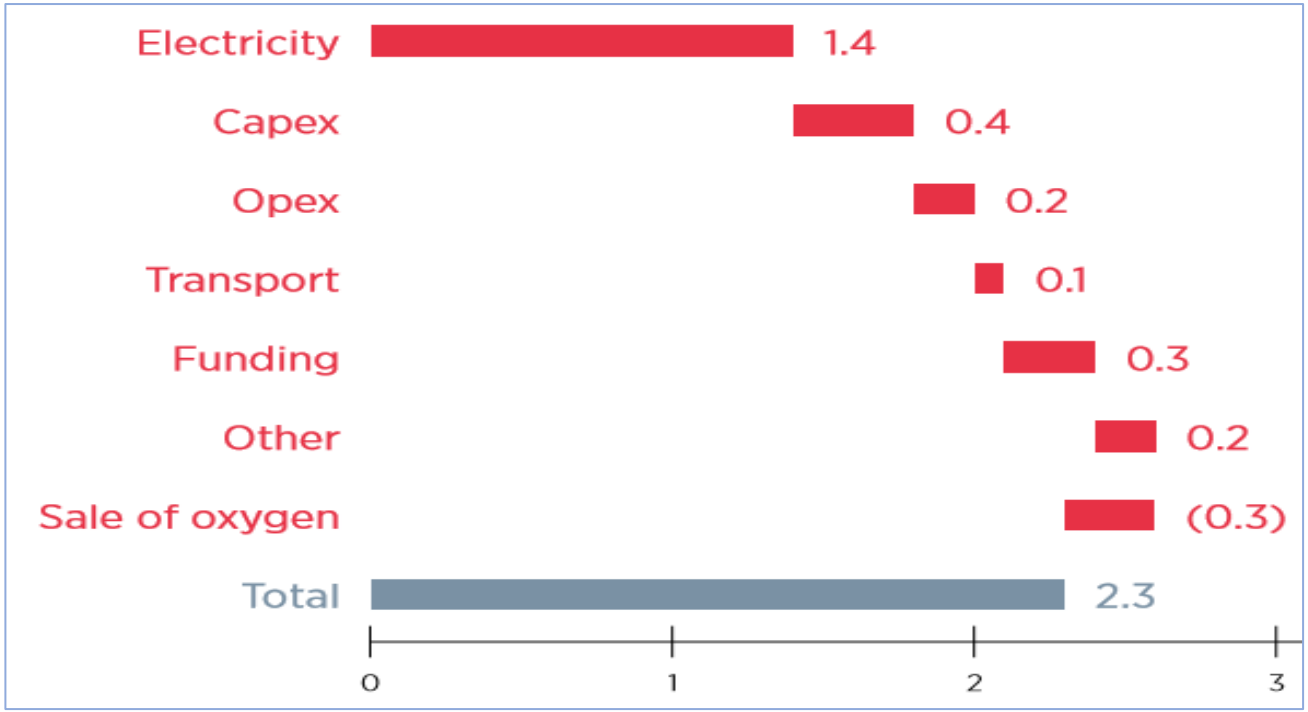
Economic benefits & challenges of hydrogen from renewables

Renewables & hydrogen | Benefits & challenges

Further scale for cost reduction & gross-added value (GVA) contribution



Renewables & hydrogen | Costs & opportunities

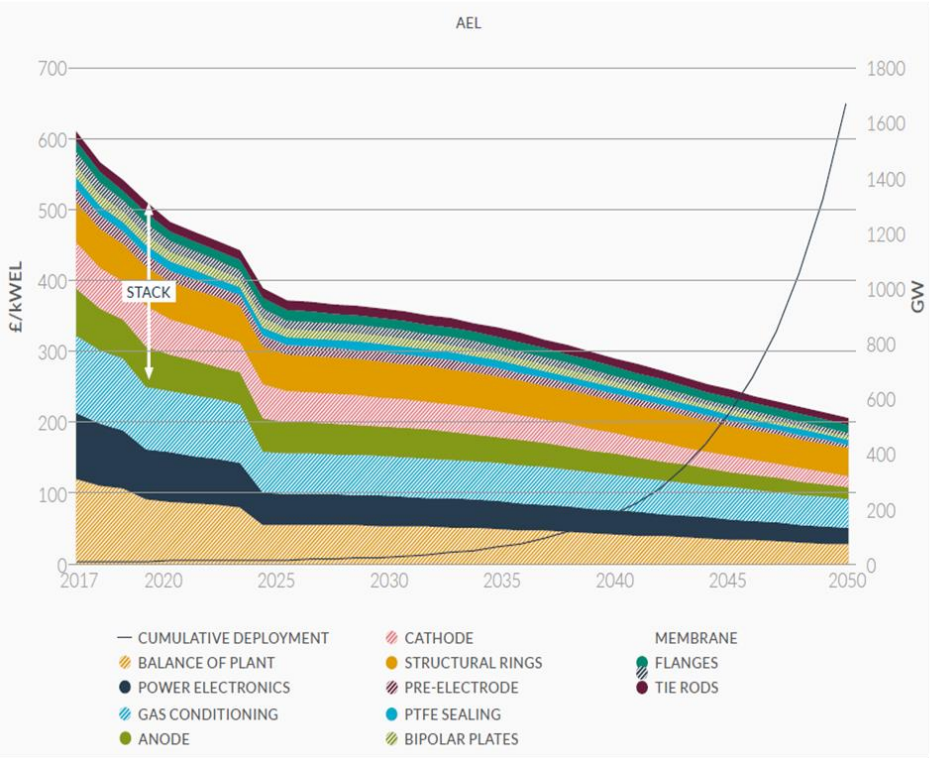


Example of green hydrogen cost breakdown (€ per kg, electricity: €25/MWh)

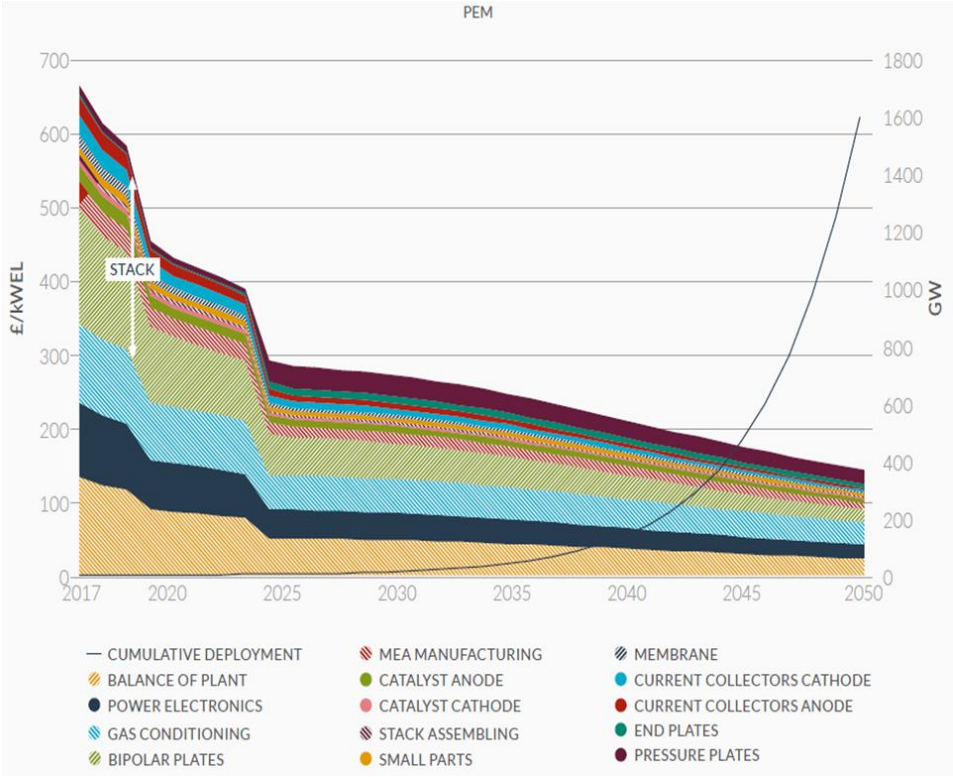
Ref: NIB (2017), http://profadvanwijk.com

Electrolyser installation, CAPEX breakdown & reduction by 2050

AEL electrolysers



PEM electrolysers



Ref: ORE Catapult (2020)

UK offshore wind – hydrogen strategy:

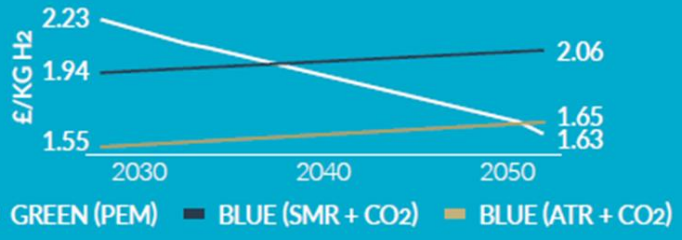
Solving the integration challenge

ENERGY SYSTEM

The UK energy system requires 130TWhr to over 200TWhr hydrogen in 2050, to integrate 75GW, or more of offshore wind.

GREEN AND BLUE HYDROGEN

Green hydrogen from offshore wind costs less than blue hydrogen by 2050*, although factors including more rapid adoption of electrolysers, swings in natural gas prices, leakage of natural gas, or cheaper blue hydrogen generation technologies, could change this picture.



Hydrogen production from natural gas with CCS might not be a necessary part of a net-zero UK energy economy in 2050.

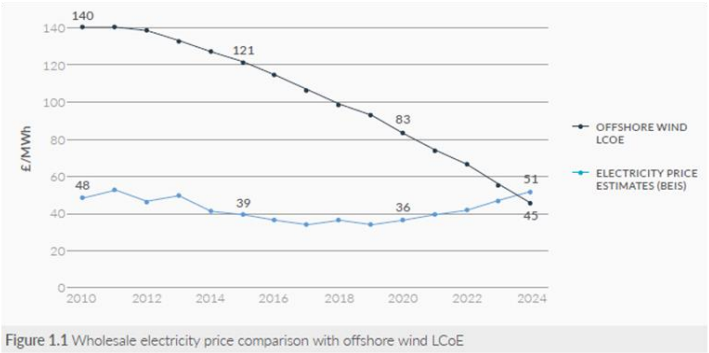
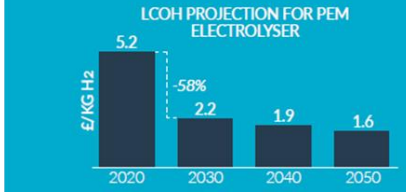


Figure 1.1 Wholesale electricity price comparison with offshore wind LCoE

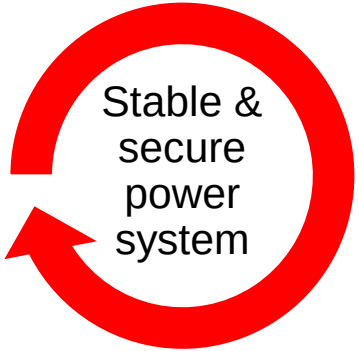
COST REDUCTION

Most of the cost reduction for green hydrogen from offshore wind occurs by 2030, by which point it can meet a significant part of energy demand.



Challenges of power systems & Potential benefits of green hydrogen

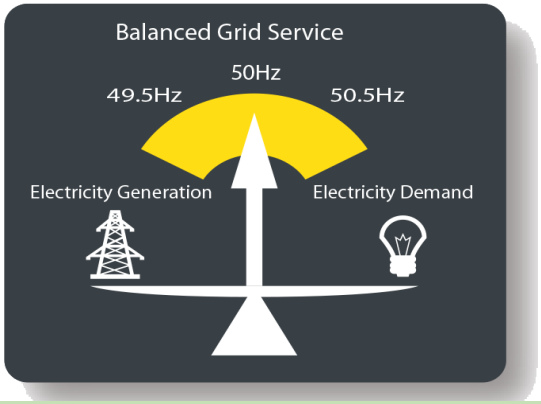
Power system stability & Grid services



Grid Services Requirements:

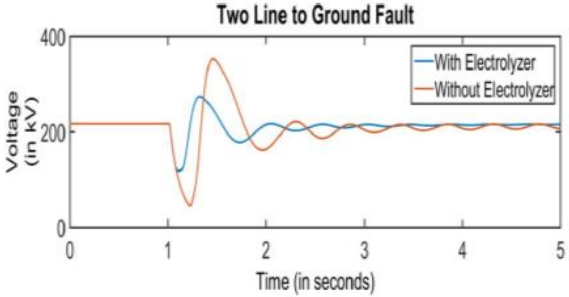
- Grid frequency at 50 Hz
- Load demand = Electricity supply

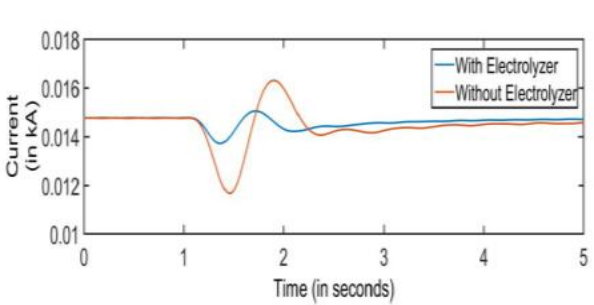
J. Laguipo, P. Leahy, V. N. Dinh (2019) EirWind Deliverable D5.4 Report

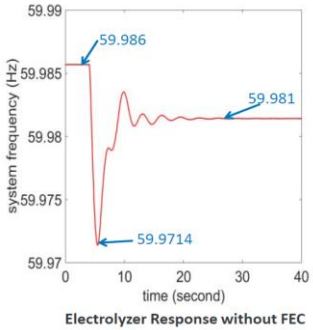


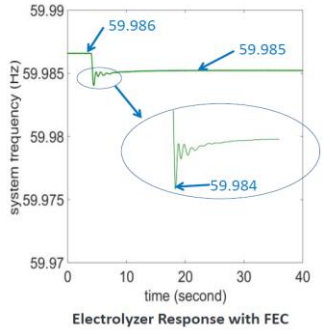
Reduction in transients created from faults with electrolyzers in the grid

US DOE (2017) Role of Electrolyzers in Grid Services: Test Results

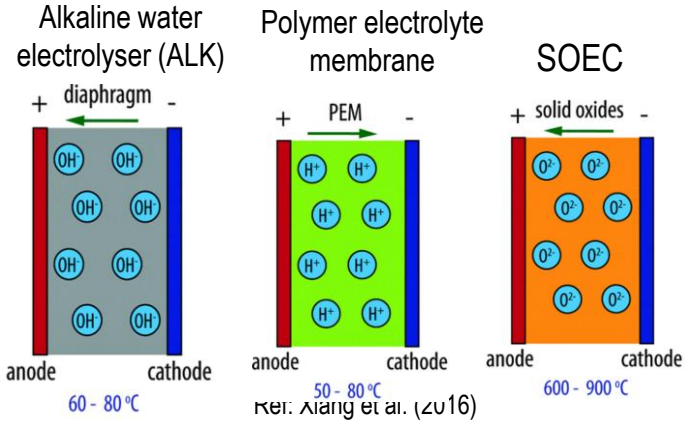








Power system stability & Grid services



Ref. Xiang et al. (2016)

Service Name	Abbreviation	Requirements
Fast Frequency Response	FFR	2 – 10 sec
Primary Operating Reserve	POR	5 – 15 sec
Secondary Operating Reserve	SOR	15 – 90 sec
Tertiary Operating Reserve 1	TOR1	90 sec – 5 min
Tertiary Operating Reserve 2	TOR2	5 – 20 min
Replacement Reserve – Synchronised	RRS	20 min – 1 hour
Replacement Reserve –Desynchronised	RRD	20 min – 1 hour

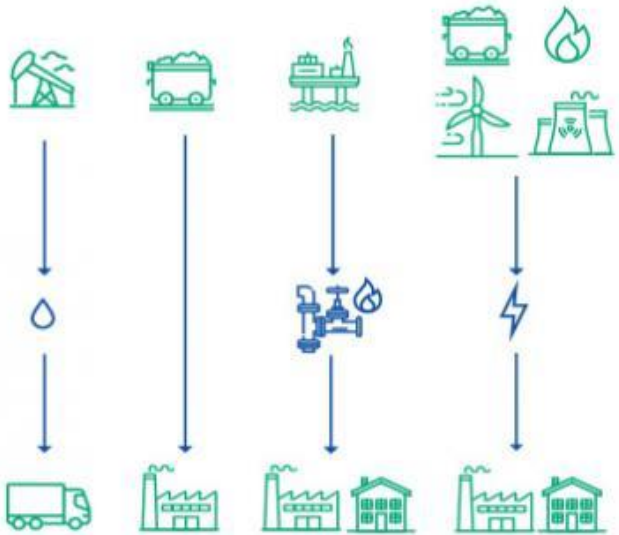
Grid service revenue

Operation condition	ALKE	PEME
Variable operation	0.2 sec < 1 sec	0.2 sec < 1 sec
Warm start	1-5 min	< 3 sec < 30 sec
Cold start	2 hours 2 hours	5 min < 7 min

P. Pereira, P. Leahy, V. N. Dinh (2019) EirWind Deliverable D5.7 Report

Future integrated energy systems

The energy system today :
linear and wasteful flows of energy, in one direction only



Future EU integrated energy system :
energy flows between users and producers, reducing wasted resources and money

Ref: https://energy.ec.europa.eu/topics/energy-systems-integration/eu-strategy-energy-system-integration_en

Global hydrogen development with implications on Vietnam

Domestic R,D&D in whole value chain: Most important

Cheaper electrolyser system, electrode, catalysts:
E.g. Iron and nickel (abundance on Earth), would replace precious metals ruthenium, platinum and iridium that up until now are regarded as **benchmark catalysts in the 'water-splitting' process** - Source

Electrolyser module for offshore production of renewable hydrogen:

(EU fund call, ID: FCH-02-6-2020, Jan 14, 2020 - URL, to develop & test offshore electrolyser modules of >1MW.

Start TRL = 3, Outcome TRL = 6. Challenges to be addressed by their funded projects.

Electrolyser modules **compatible with marine environment** (including stringent safety requirements, existing delivery contracts & the difficult accessibility)

Hydrogen storage:
Cost cheaper with scale, technology & efficiency improvements – by up to **40% as ammonia** & **80% as liquid hydrogen**

Green Hydrogen Hub (R&D, production, storage, ports, export)

Example: NEOM Green Hydrogen Project - Saudi Arabia

Schematic of Jetty

Ammonia Tanker

Key Features

- Futuristic mega-city, powered 4GW of wind & solar power
- Supply 650 Tons Per Day of Carbon-Free Hydrogen
- Fuel shipped as ammonia to global markets then converted back to hydrogen. Ammonia production is expected to start in 2025

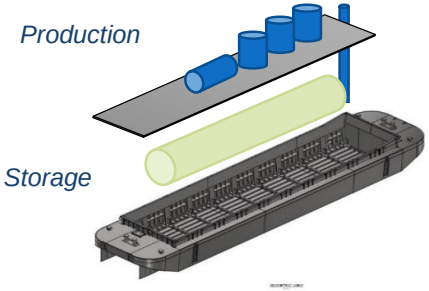
ABL Group's Scope of Work

- Engineering review of FEED design
- Pre-EPC risk review to establish safety, cost and schedule risks pre-detailed design.
- EPC tendering support
- EPC tender review
- Support during detailed design and construction

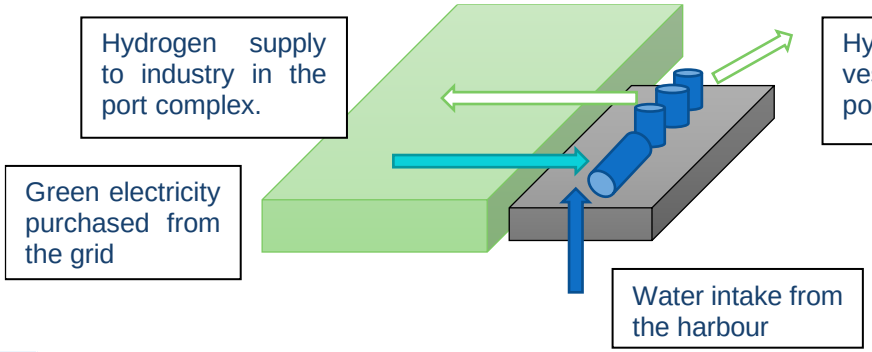
Client:
Air Products Ltd

Offshore & mobile hydrogen production systems

Example: ABL Group Green Hydrogen Production Barge



The Barge



The Concept

- Develop solution for local hydrogen production within a typical medium sized commercial port/ harbour readily installable, with minimal infrastructure, to support the adoption of hydrogen as a marine fuel.
- Validate the modelling assumptions such that other UK ports can be evaluated for suitability and roll out of the concept
- Develop barge concept designs to suit a range of demand sizes
- Further develop a selected concept detail to prepare for a future demonstration phase

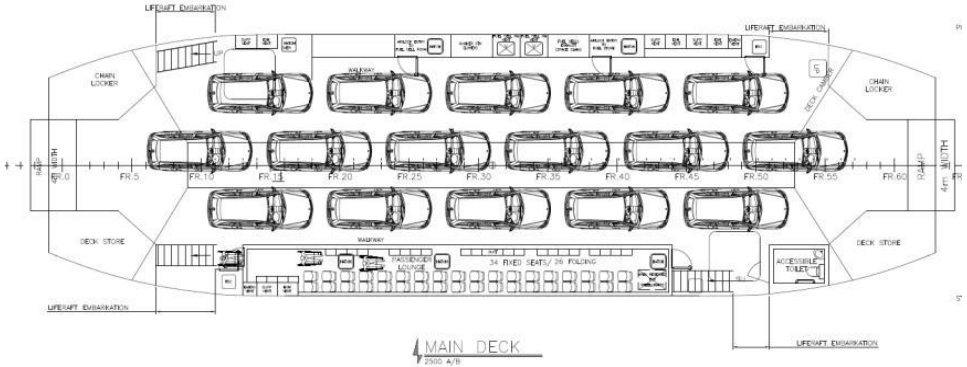
Client: DFT/ INNOVATE UK

Increasing green hydrogen demand & applications

Example:
ABL Group Hydrogen-fuelled (Fuel Cell) Ferry

Key Features:

- Zero Emission Vessel
- Double-ended sea-going ferry, 120 passengers & 16 cars or two trucks
- To be first Hydrogen fuel-cell powered vehicle and passenger ferry in the UK
- Working with Class and Maritime and Coastguard Agency to agree design and compliance approach in this new area.



Source: https://abl-group.com/uncategorised/first-renderings-completed-from-hydrogen-powered-vessel/

Featured in BBC: https://www.bbc.com/news/uk-scotland-61988917

Hydrogen safety standard and regulations

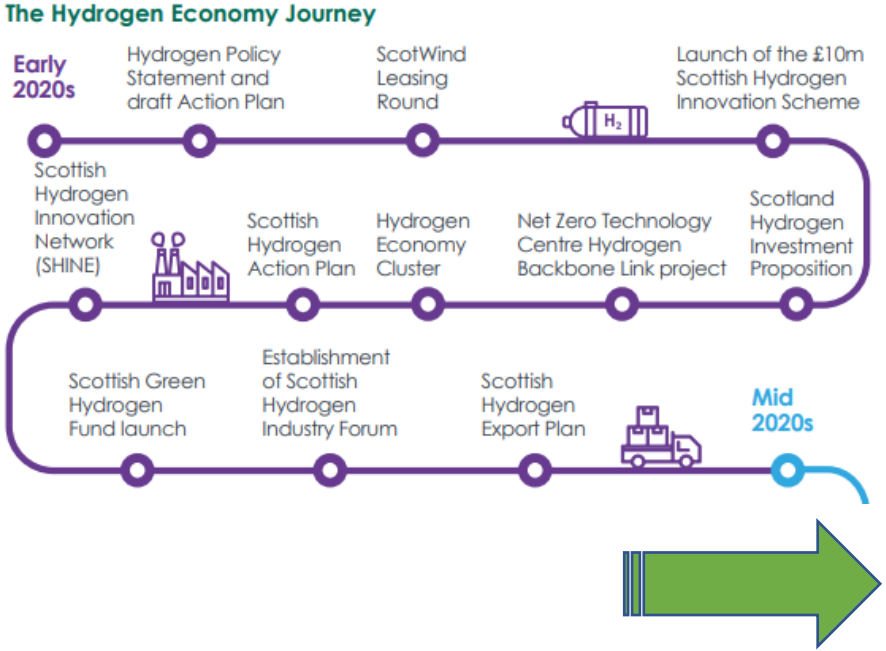
Example: Fuel-cell manufacturer safety representative

ABL Group acted as a Representative for

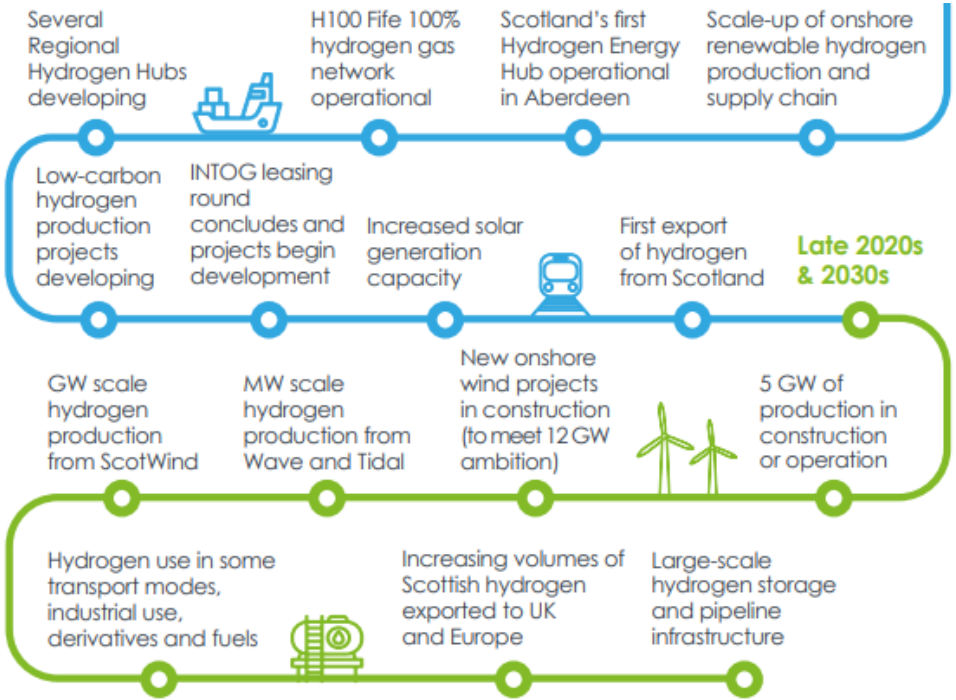
- Internal/external securing/wrapping of the PureCell ®Model 400 for transportation
- Loading and securing onto a trailer for road transportation to warehouse for boxing
- Wooden box packaging
- Lashing/securing onto a trailer for road transport to loading port in Laem Chabang
- Completed, 300 units during 2016 – 2020 (in Thailand)

Client:
Doosan Fuelcell America

Step-by-Step Development of Hydrogen Economy



Example: Scotland Hydrogen Economy Journey



Ref: www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2022/12/hydrogen-action-plan/documents/hydrogen-action-plan/hydrogen-action-plan/govscot%3Adocument/hydrogen-action-plan.pdf

Suggestions for green hydrogen industry development in Vietnam

Nên tập trung:

- Phát triển công nghệ trong chuỗi giá trị: máy điện phân, xúc tác, điện cực, thiết bị lưu trữ & phân phối, thiết bị sử dụng hydrogen & ammonia. Thông qua hợp tác với các nước
- Nghiên cứu khoa học, đào tạo nhân lực đa ngành chuyên sâu
- Ban hành tiêu chuẩn an toàn, kỹ thuật
- Quy hoạch các dự án sản xuất hydrogen, nhất là sau 2035 và từ điện gió ngoài khơi, điện sóng biển
- Hỗ trợ các nhà phát triển công nghệ và dự án sản xuất tiên phong

Cần xem xét kỹ:

- Sản xuất hydrogen quy mô lớn quá sớm mà thiếu các chuẩn bị cần thiết
- Nhập khẩu toàn bộ công nghệ

Không nên:

- Sản xuất hydrogen từ điện sa thải
- Sản xuất hydrogen ở vùng thiếu nước ngọt

Further information: https://abl-group.com/renewable-energy-engineering-consultants/hydrogen/

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