Lessons Learned from Large Scale H_2 Production Project

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Shell's net-Zero Emissions Target

Shell's operating plan, outlook and budgets are forecasted for a ten-year period and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next ten years. Accordingly, they reflect our Scope 1, Scope 2 and Net Carbon Intensity (NCI) targets over the next ten years. However, Shell's operating plans cannot reflect our 2050 net-zero emissions target and 2035 NCI target, as these targets are currently outside our planning period. In the future, as society moves towards net-zero emissions, we expect Shell's operating plans to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

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This presentation may contain certain forward-looking non-GAAP measures such as cash capital expenditure and divestments. We are unable to provide a reconciliation of these forward-looking Non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those Non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc's consolidated financial statements.

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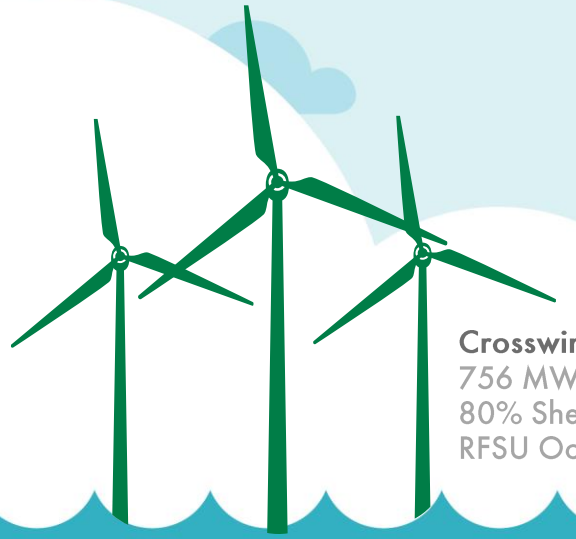
Project:
Holland Hydrogen 1

TIMELINE

2020	2021	June 2022	2023	2025
Project Initiation	Vendor select & DG3	Final Investment Decision	HH1 Construction, HKN online	Commissioning and H_2 supply



Crosswind
756 MW capacity
80% Shell Share
RFSU Oct 2023

Holland Hydrogen 1
200MW
Electrolyser

H_2

Peak production: 80 t/pd
Annual production: 20 ktpa

Pernis

Daily use: 550 tpd
Flexible production

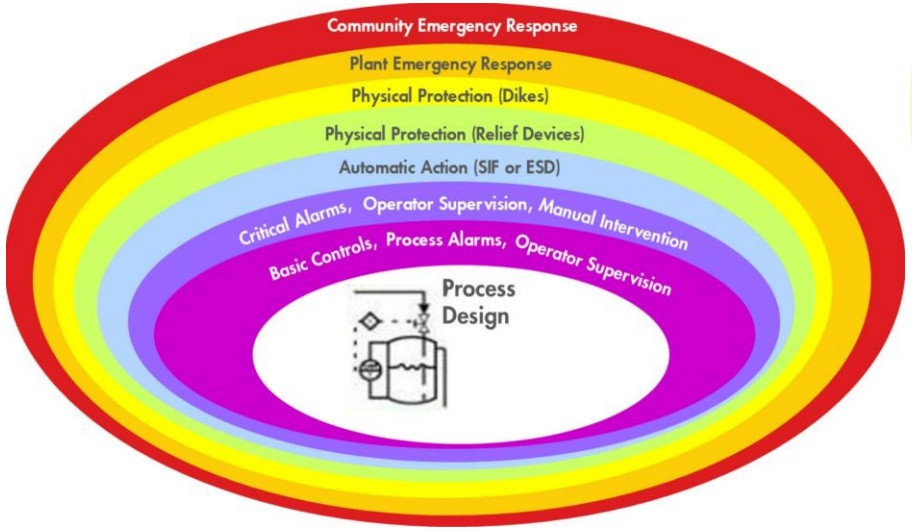
Mobility platform
~ 2300 trucks

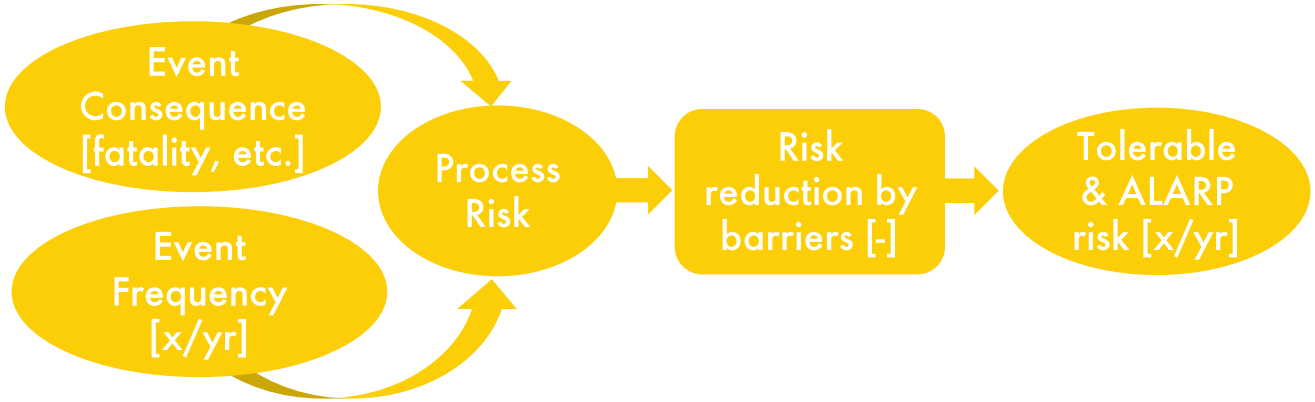
Future use:
Marine (RED III)
Industry (RED III)

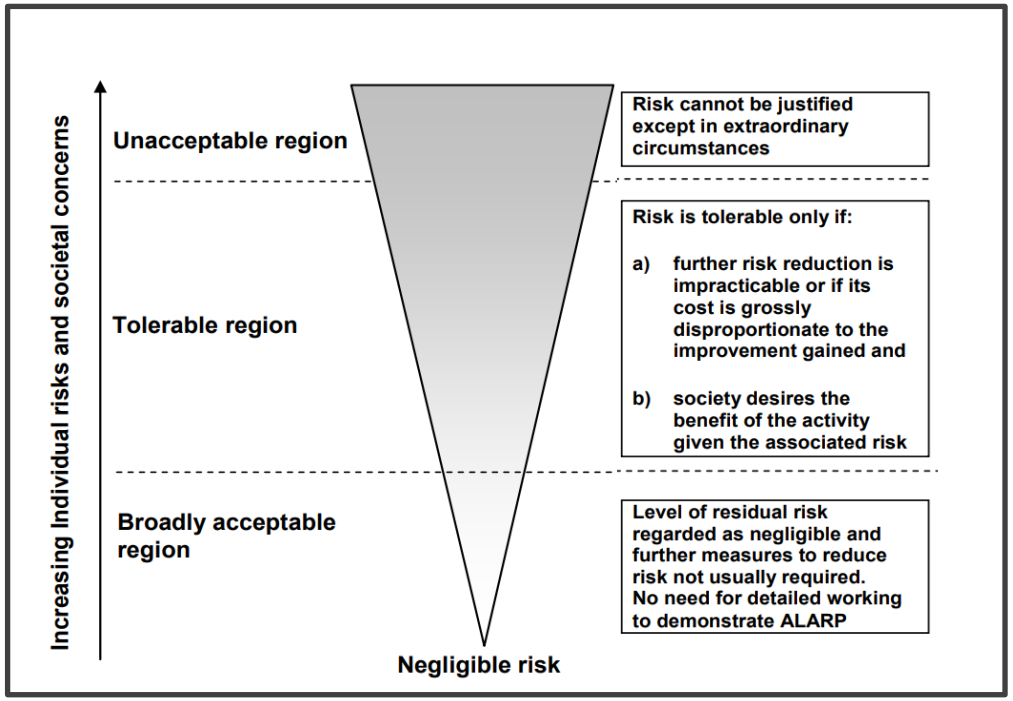
Holland Hydrogen 1
Construction

Safe Design Philosophy

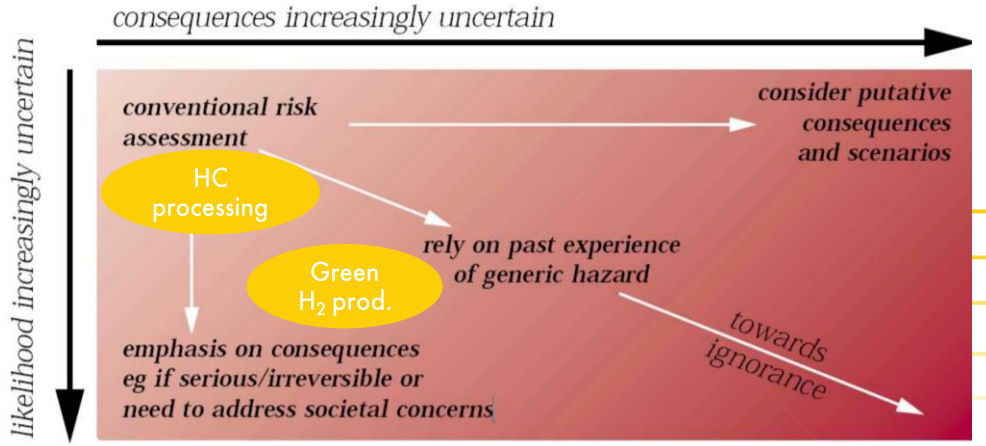
- Laws, regulations
- Codes & standards
- Vendor best practices
- Internal Shell standards
- Eliminate / substitute hazards
- Reduce risk to ALARP by adding valid barriers







Risk Assessment Challenges for H_2 Production Plant Designs



- Gaps in laws, regulations codes and standards
- Uncertain event frequencies and consequences
- Standard tools for leak effect / QRA modelling not always sufficient
- Verification of effectiveness of novel barriers

→ Project risk and potential inconsistency in safety standards across the industry

→ Potential overdesign of safeguarding, avoidable cost

→ Additional safety margin or comprehensive studies including model qualification

→ No credit for risk reduction unless validated!

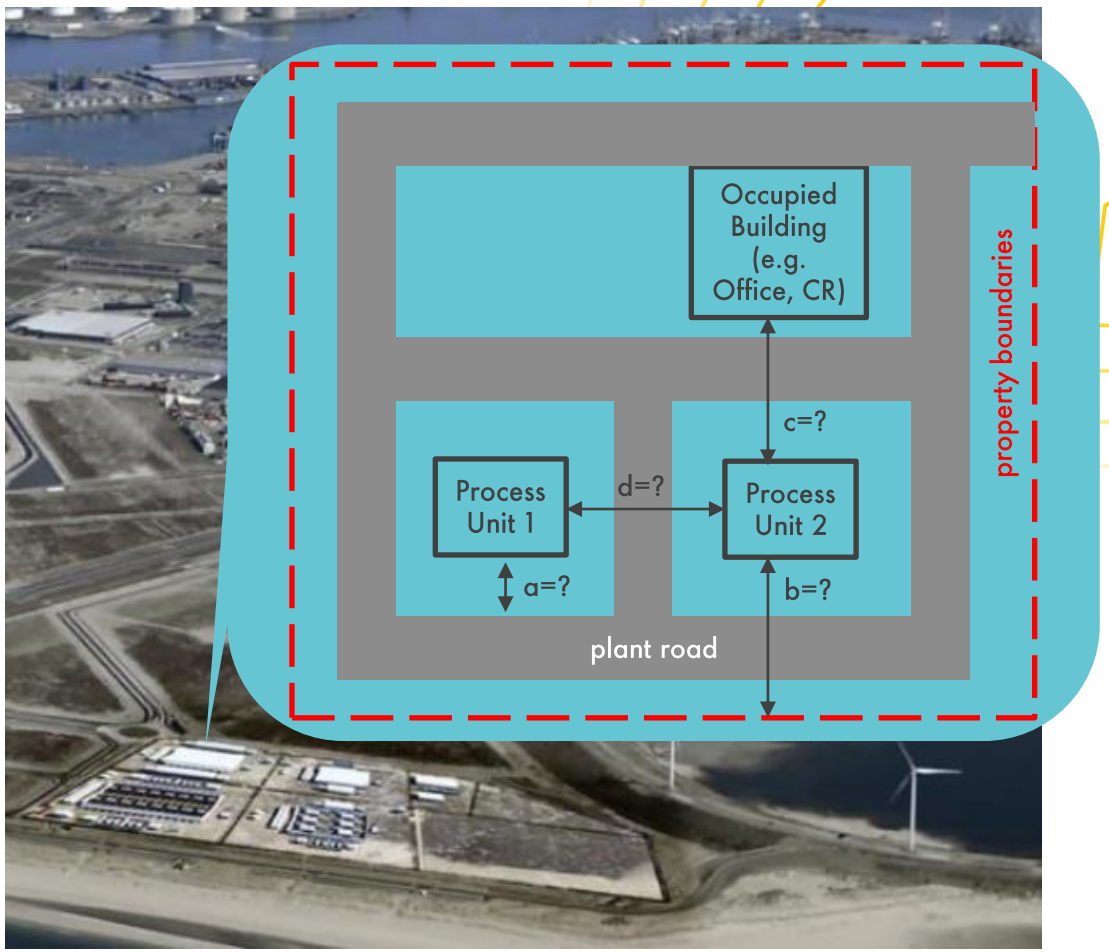
Site Selection & Layout

Drivers

- People Health / Safety (occupied building risk, access & escape, public risk, noise)
- Availability (asset damage risk, etc.)
- Cost effectiveness (piping length, insurance, barriers)
- Constructability & Maintainability

Challenges

- Hardly dependable guidance by OEM, regulations, codes & standard
- Minimum Separation distances = f (operating pressure, congestion / confinement, mitigation)



- Time-consuming and costly iterative, multi-disciplinary optimization
- Potential cost escalation (in particular for small plots)

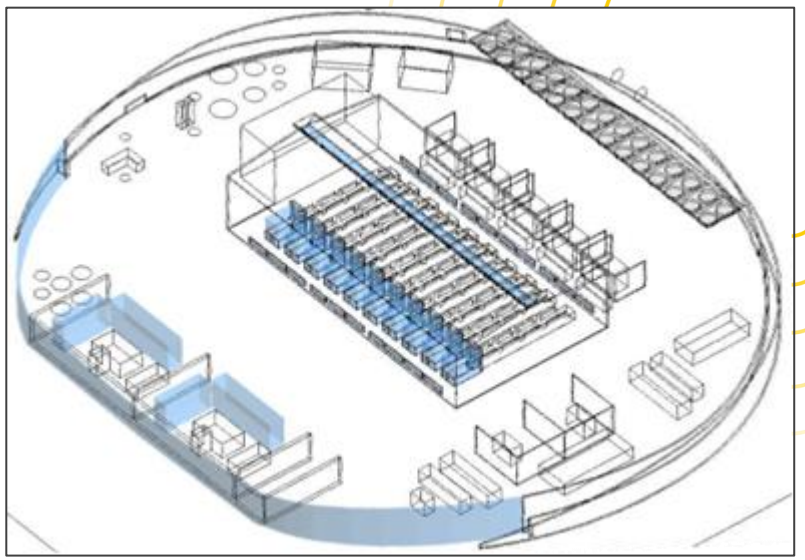
Electrolyzer Building

Objective & Requirements:

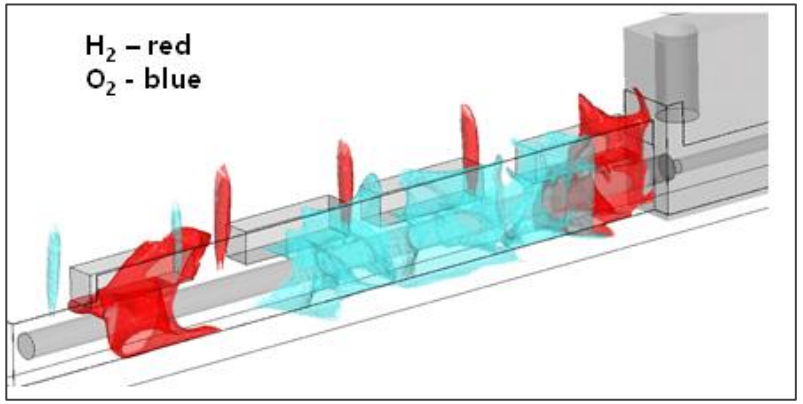
- Climate control as per OEM requirements
- Minimum ventilation as per ATEX standard for zone NE
- Fire & Explosion (F&G) safety and structural integrity

Challenges

- Building excluded from vendor package
- Uncertainties in H_2 leak rates / frequencies
- Complex CFD studies for evaluation of ventilation and explosion risk



Geometry for HVAC design investigations



Calculated H_2 clouds (LEL) and oxygen clouds (23 %-vol)

Conclusion: H_2 Industry needs concerted efforts

Common awareness and standardization:

- Safe design methodologies
- Major hazardous scenarios and safeguarding requirements
- Electrolyzer plant specific separation distances

Advancement in risk prediction:

- Global sharing on equipment failure and barrier performance
- H_2 ignition / explosion probability and consequence prediction

Equipment design and testing:

- Development / validation of effective barriers and performance criteria
- Electrolyzer OEM support in design integration or fully modular designs

Q&A