WHEN TRUST MATTERS

How to make Hydrogen Bankable

29. Windenergietage, 2021

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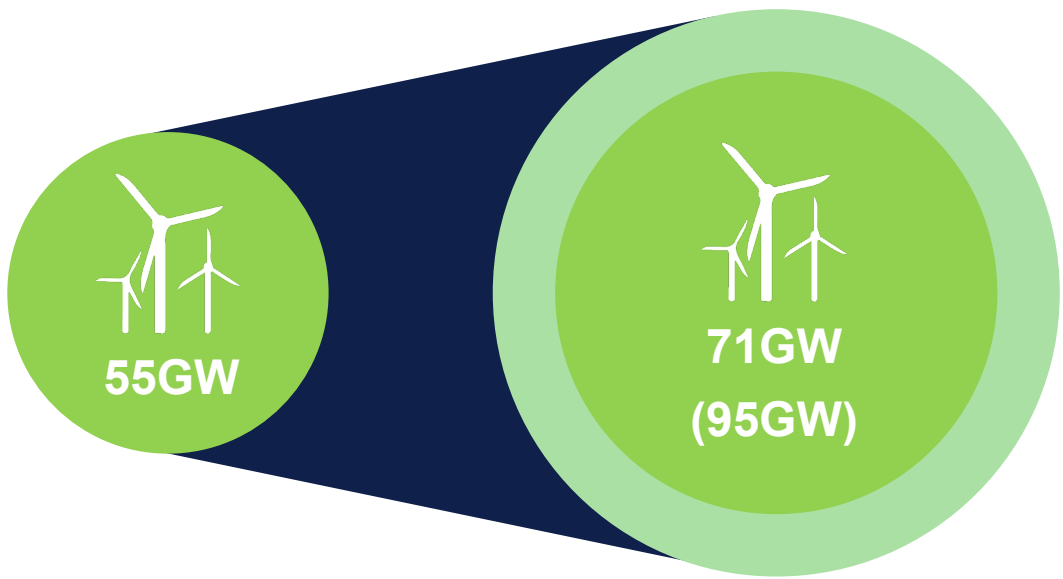
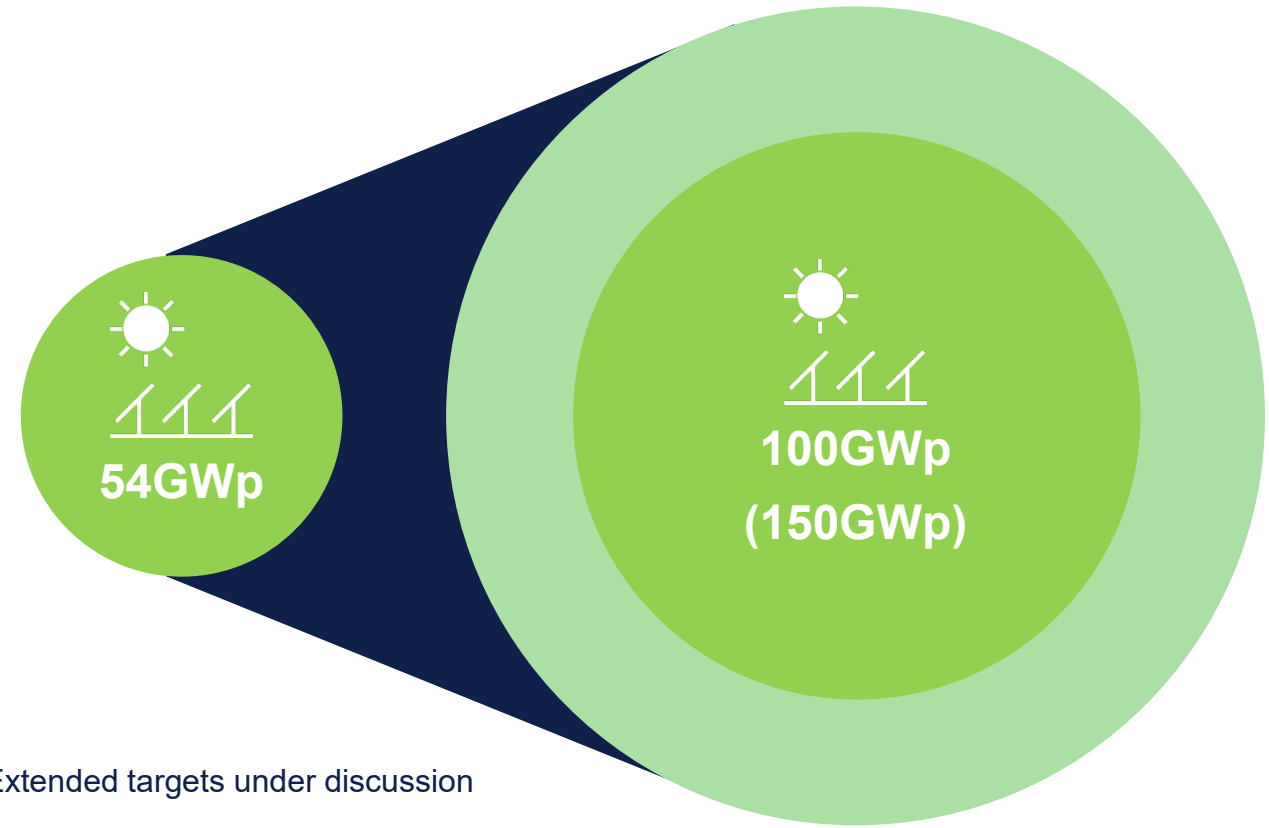
Challenging Growth Towards 2030 – Onshore and Solar

Onshore Wind capacity



Solar capacity



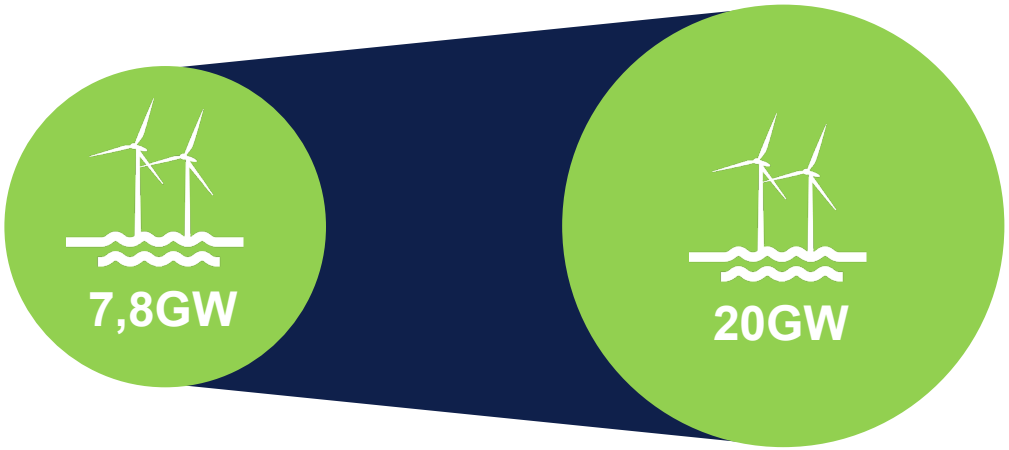
Agreed targets

Extended targets under discussion

Offshore Wind and Green Hydrogen

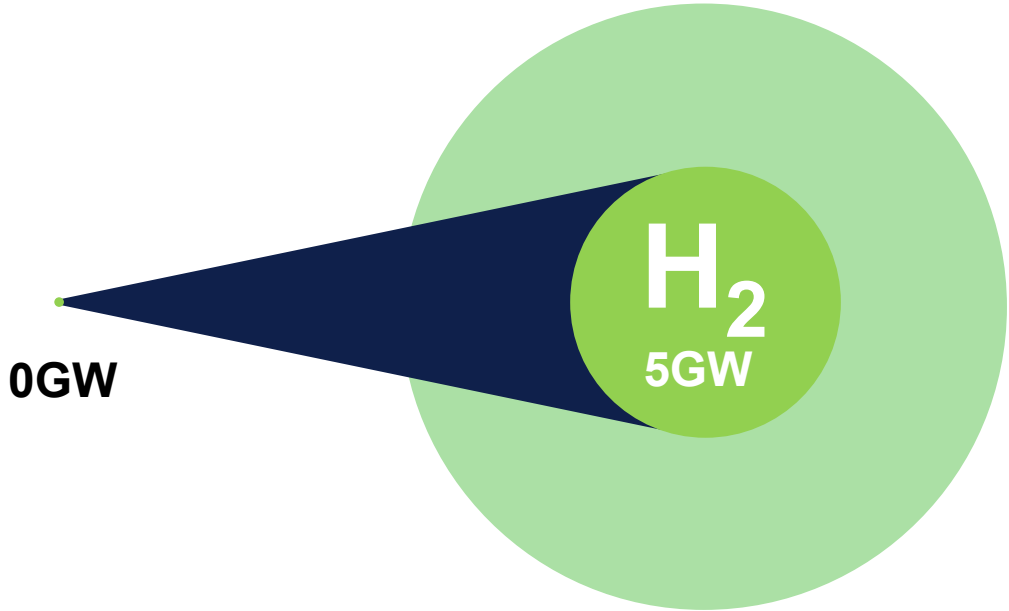
Offshore Wind capacity

2020 2030



Green Hydrogen Capacity

2020 2030

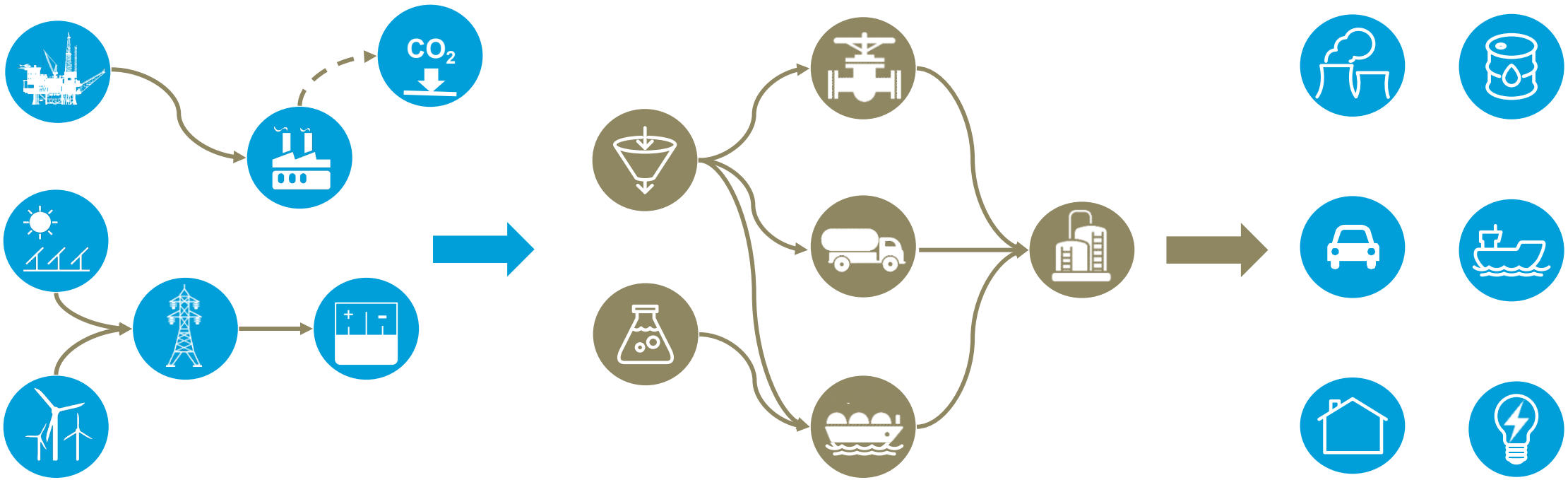


Large challenges with a high degree of regulatory, technological and commercial uncertainty in an extremely short time frame

Hydrogen As Key Energy Carrier and Storage Option

- Hydrogen and hydrogen-derivates are the most promising solution to decarbonize hard-to-electrify sectors
- Hydrogen today is expensive and inefficient due to energy losses in value chain, and will only be competitive globally vs incumbent technologies in 2040s
- Green hydrogen will dominate over time, mainly from dedicated renewables sources

Comprehensive View on the Hydrogen Ecosystem



DNV offers a wide range of both technical and business advisory services and, with broad expertise across the energy and maritime industries, we are in a unique position to cover the whole hydrogen value chain.

Assessment and Quantification of Risks and Rewards

1	Acceleration of authorization procedure by certification and conformance testing	5	Efficiency, performance and comparability of electrolysers and electrolyser technologies
2	Quality, reliability, availability and maintainability of electrolysers	6	Control, safety technology, converters, balance of plant, management
3	Continuous hydrogen quality according to specification	7	Safe structures and transport systems
4	Safety standards for production and storage	8	Support safety and reliability standards for the planning, construction and operation of plants

TDD and Certification – Two Sides of the Same Coin

Certification

- Generation or common best practices leading to an independent and reliable standards base
- Continuous development and integration of technical progress and practical experience to update standards base
- Commonly accepted evaluation and assessment criteria and rules to significantly speed up permitting process, based on commonly recognized principles and parameters
- Conformance testing for standard adherence

Due Diligence

- In detail review and assessment of existing implementation
- Substantially faster assessment due to predefined assessment criteria and procedures
- Significant reduction of effort due to preceding component, assembly and project certifications.
- Reliance on commonly accepted evaluation standards to reduce ambiguity and to make subjects comparable

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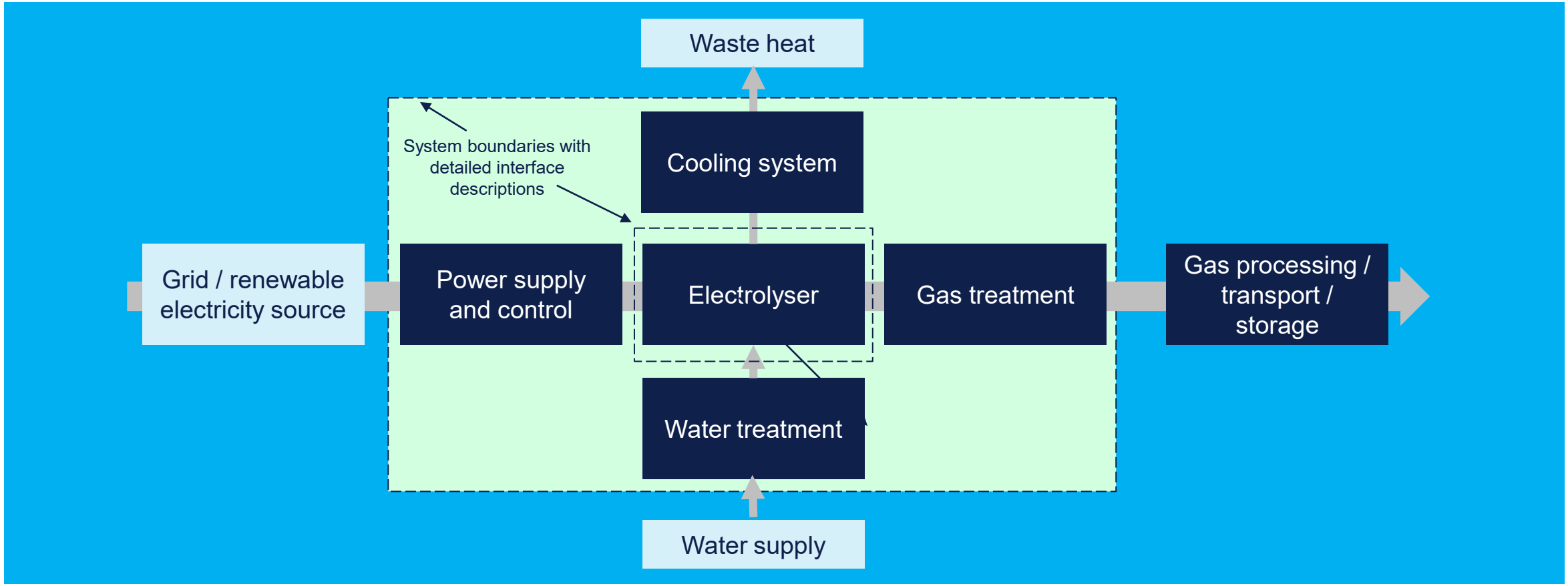
Complexity of Green Hydrogen Production Systems



Component certification

Assembly certification

Project certification

For each box/type these will be defined following the three main principles:
Safety / Performance / Regulatory

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Exemplary Scope of Work – Ammonia Production Case

Item	Description (simplified)
Site Assessment	Site location and site conditions including the geotechnical/topographical conditions Site clearance/preparation and land leasing Environmental/Social Impact Assessment
Solar PV Plant	Solar resource and impact of local site /weather conditions on the facility Site energy production assessment Review of technical site implementation (EPC, O&M contracts)
Wind Plant	Wind resource and impact of local site /weather conditions on the facility Site energy production assessment Review of technical site implementation (EPC, O&M contracts)
Desalination and purification plant	Design and installation of the desalination plant EPC and O&M conditions
Hydrogen Production Unit	Risks assessment of technology chosen Quality assessment of major equipment suppliers/EPC contractors (time, budget) Compliance with good engineering practice (production, service) Design and installation of the hydrogen production unit (EPC, O&M) Compatibility with the solar-PV and wind plants (generation/consumption balance) Compliance with national legislation, regulation and technical standards for hydrogen production, storage and use

Exemplary Scope of Work – Ammonia Production Case

Item	Description (simplified)
Air Separation Unit	Risks associated with technology chosen Design and installation of the air separation unit (EPC, O&M)
Ammonia Production Unit	Risks associated with technology chosen Validity of safety measures, compliance with good engineering practice Design and installation of the ammonia production unit (EPC, O&M) Capacity assessment to meet the expected production volume, considering the supply of synthetic raw materials such as hydrogen, nitrogen and electric energy Impact of single equipment failure (N-1 contingency) on production capacity Compliance with national legislation, regulation and technical standards for ammonia production, storage and use
Ammonia Transportation and Storage	Design and installation of the ammonia transportation and storage facility (EPC, O&M) Validity of safety measures, risk assessment
Levelized costs of Green Ammonia / Hydrogen	Based on provided & reviewed CAPEX and OPEX for each main equipment/system, availability/annual production, discount rate and expected project lifetime
Construction Schedule / Project Costs	Critical path assessment and evaluation of contingency measures
Greenhous Gas Emissions	Assessment of the impact to the environment due to the possible GHG emissions in the whole production process

Technical Due Diligence in Real Life

Large Scale Liquid Hydrogen Releases

Develop a scope and conduct a series of large-scale liquid hydrogen release tests to provide valuable experimental data for model validation to investigate dispersion, pooling, fire and explosion properties of free, impinging and confined, ventilated phenomena.

Pipe Selection for a High-Pressure Hydrogen Pipeline

Guidance regarding acceptable options for pipe grade and wall thickness applicable to a potential new pipeline. The pipeline would be constructed to transport high pressure hydrogen. Development of options allowed by two different approaches to determining the required material properties, wall thickness, and design factors (ASME B31.12-2019).

Vendor Due Diligence

Overall assessment and benchmark on products line-up and a technical deep dive into innovation stratieges. The assessment was to assure the manufacturer was at a competative level and that their product and innovations were realistic and promising.

Hydrogen Wind Turbine

Feasibility assessment for a potential investor in a greenfield hydrogen production portfolio. Combination of an onshore wind turbine and an electrolyser in first phase, which would supply hydrogen to nearby third parties. In future phases, the project would be expected to grow to several hydrogen wind turbines on- and offshore.

Key Takeaways

1. Certification and Technical Due Diligence are interdependent and effective ways to reduce complexity and to enable reliable and comparable assessments

2. Commonly developed certification and assessment criteria lead to a significant reduction of risks and uncertainty

3. Reduction of risks and uncertainty while driving technical and commercial reliability will foster bankability

Thank you!

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