Royal HaskoningDHV
Enhancing Society Together

Hydrogen electrolysers

Avoiding and mitigating Hazards

Peter Winkelman
14 December 2023

Source: ISPT: A one GigaWatt Green-Hydrogen plant



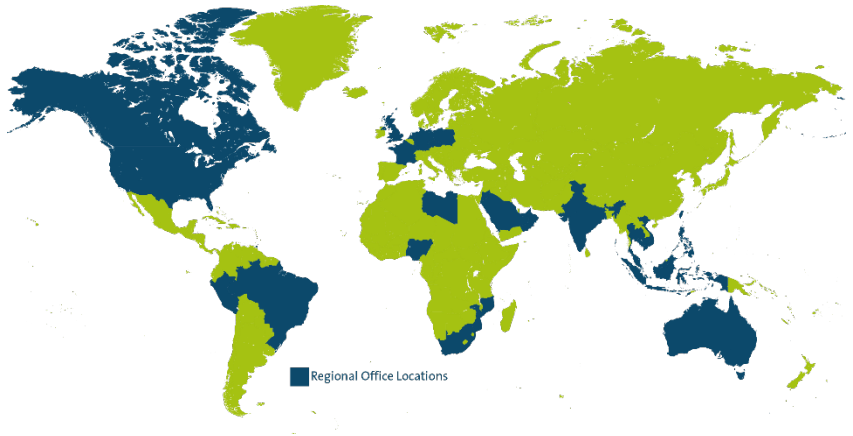

About us

Royal HaskoningDHV is an **independant** agency that integrates 140 years of consultancy and engineering knowledge with digital technology and software solutions.

Together with customers and partners, we work on innovations and smart solutions for a more **sustainable future** and make the lives of large groups of people worldwide easier, healthier and safer.
Enhancing Society Together!

Top-3 engineering firm Netherlands (Technisch Weekblad)
Global #37 (Engineering News-Record magazine)

6.000 collegues work from
65 offices on projects in **100+ countries**



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Our purpose is to have impact through our projects on:

1. **Safety & Well-being**
2. **Climate change**
3. **Biodiversity & Natural systems**
4. **Resources & Circularity**
5. **Social value & Equality**

Realisation of this purpose is reflected in our presentation

hydrogen electrolysers: avoiding and mitigating hazards

Measuring Enhancing Society Together

200+
HSE Consultants

100+
Process engineers

working from some **50** *offices* around the world

on projects in **100+** *countries*

6,000+
colleagues

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Water electrolysis historical background

- 1800 Water electrolysis discovered
- 1930 First large scale water electrolysis plant
- 1940 Steam methane reforming (SMR)
- Role of large-scale water electrolysis small for a long time
- Limited development for a long time

- Now:
  - Increased demand for Hydrogen (chemical and energy)
  - Decarbonisation: Renewed interest in large scale water electrolysis

Green hydrogen: Hydrogen produced with energy from renewable resources

COP28: Transition away from fossil fuels

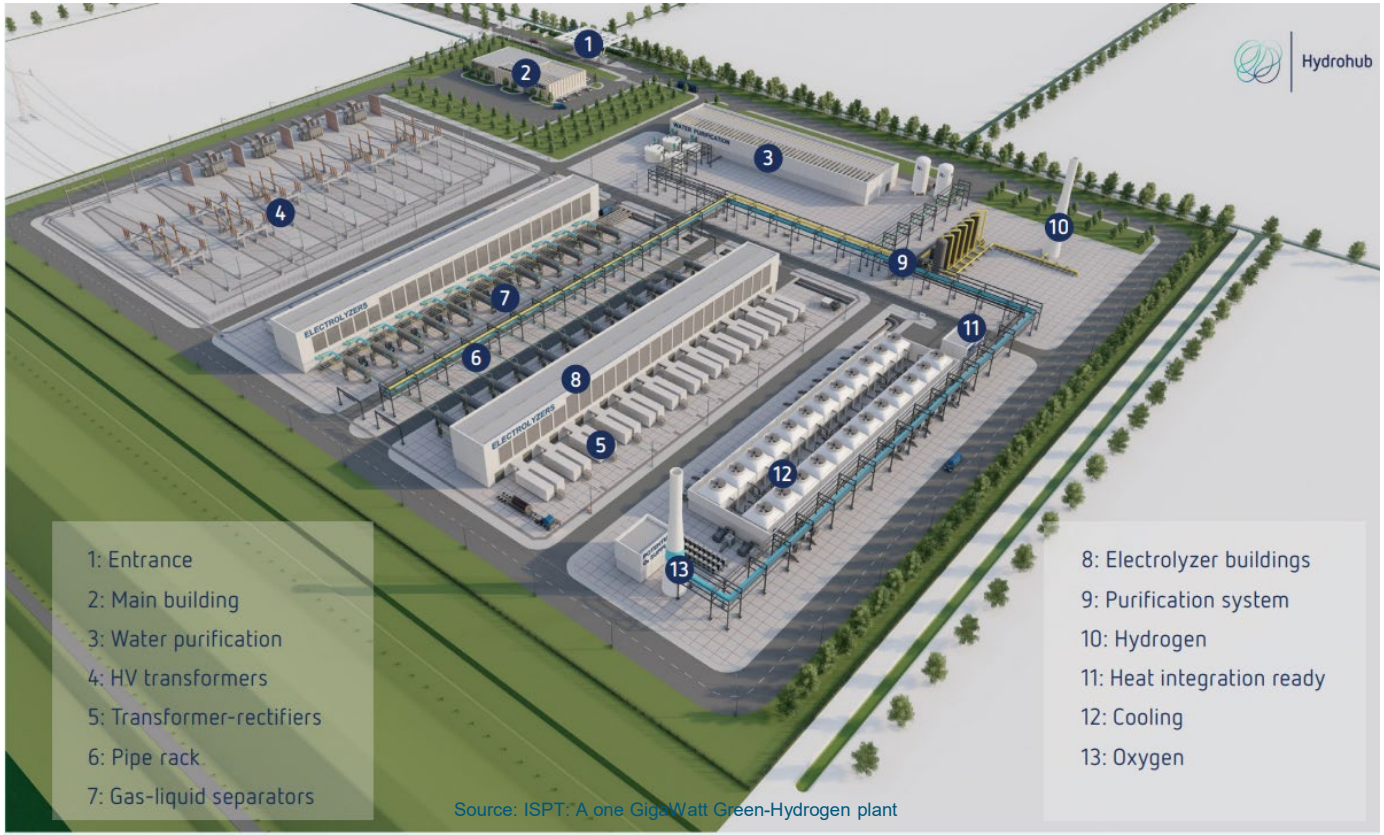
Large scale green Hydrogen electrolysis

European green deal: Large scale production of green hydrogen through water electrolysis is essential to meet CO_2 emission reduction targets.

Renewable hydrogen Goals

- Netherlands:
  - 500 MW in 2025
  - 0,5 Mt /year
- EU
  - 10Mt domestic
  - 10Mt imported

Artist impression of 1GW PEM electrolyser plant



Source: ISPT: A one GigaWatt Green-Hydrogen plant

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Focus on safety

- Larger scale means:
  - Larger electrolysers
  - More electrolysers

- Focus on safety will help to improve the design and limit incidents. This will help to maintain public support for these types of technologies.

- Experience for small sized water electrolysis plants on: Design, Operation and Maintenance

- Lack of historical data, common understanding and standardisation for large-scale

Designing with uncertainties

- Credit to give to specific barriers
- Probability distribution direct and delayed ignition
- Deflagration to Detonation Transition in equipment
- Consequence modelling of hydrogen explosions (model validity)

- Resulting in:
  - Conservative design
  - High cost
  - Delays in design
  - Delays in permitting

- Need for consensus and standardisation on safety aspects and (inherent) safe design

Joint Industry Project

- Consortium (industry, OEM's, Consultancy)
- Project phase 1 (2022): Safety aspects of green hydrogen production on industrial scale
  - Identifying gaps in knowledge
  - Special focus on fire and explosion risks associated with combination of H_2 and O_2 in equipment and buildings
- Chair: Institute for Sustainable Process Technology (ISPT)

Phase 1 (2022)

- Aim: stimulation of awareness about safety regarding large scale green hydrogen production
  - Preliminary studies in hydrogen safety evaluations regarding explosion types
  - Modelling approaches
  - Constructing draft bowties

- Link to website and public reports: https://tinyurl.com/H2Safety

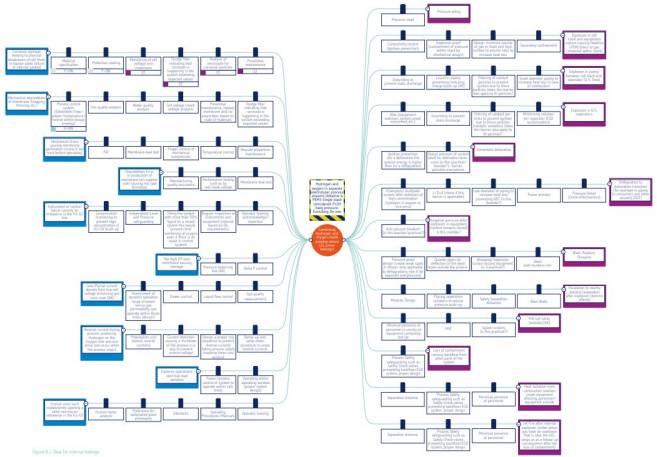
Bowtie type of causes

Causes

- Membrane/cell degradation
- Balancing line
- Process deviations from operational intend
- Human error

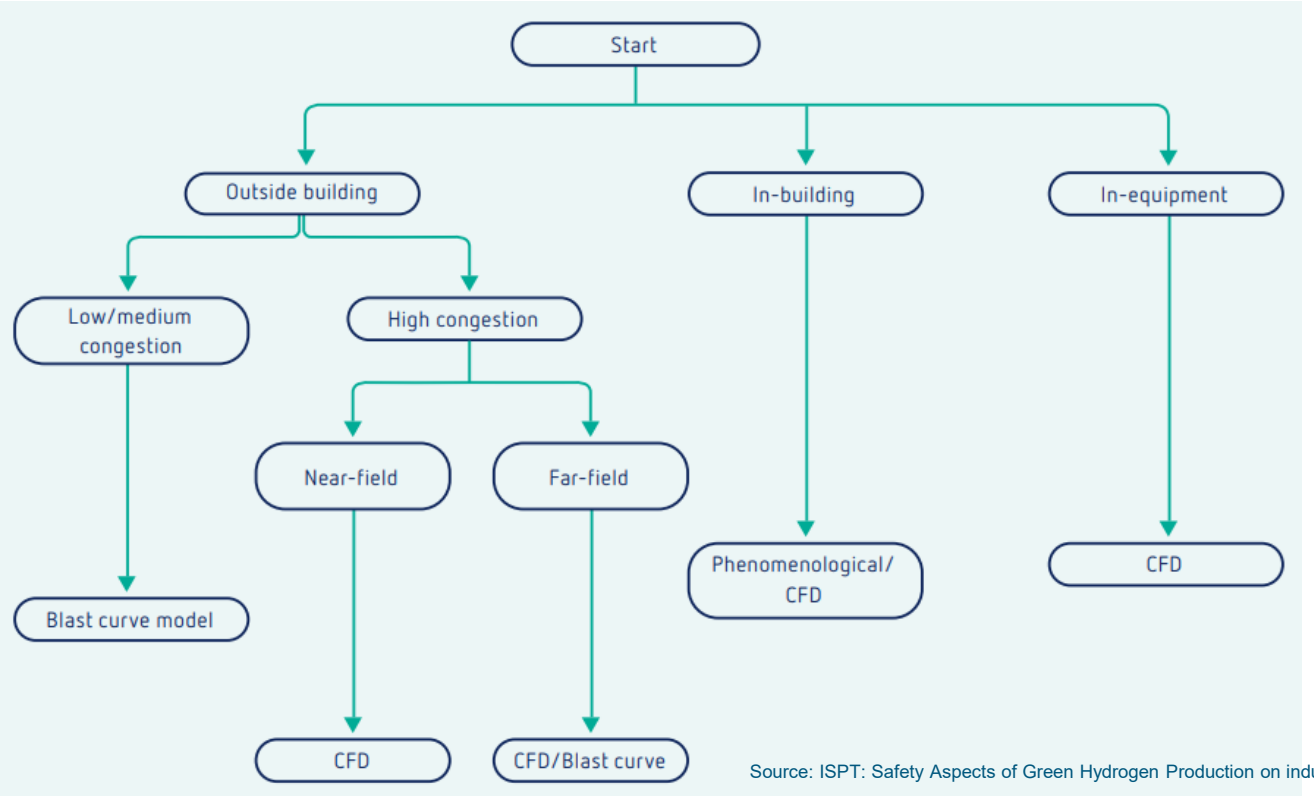
Consequences

- Pressure piling
- Deflagration or detonation
- Damage after internal explosion, such as:
  - Blast overpressure, rupture, shrapnel
  - Escalation to nearby stacks/separators
  - Hot Lye spray (AK)



Source: ISPT: Safety Aspects of Green Hydrogen Production on industrial Scale

Hydrogen explosion modelling guidance



Source: ISPT: Safety Aspects of Green Hydrogen Production on industrial Scale

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Key takeaways

- The process/chemical industry has well-established tools to assess the safety, that also applies to the design of large-scale hydrogen electrolysers.
- There is a lack of historical and validated data on failure frequencies, probability of failure on demand and probability of ignition at GW scale.
- Data and corresponding models on deflagration and detonation are not as well developed for hydrogen as they are for hydrocarbon systems.
- This will require a conservative approach in assumptions and models for the design and operation of upcoming large-scale deployments.

Phase 2 (2023 – 2024)

Goals

1. Achieve an understanding of credible hazard scenarios for electrolyzers
2. Develop, align and improve alignment of permitting, user and supplier requirements on process safety
3. Prepare new guidelines and practices including industry wide minimum safety requirements.
4. Provide technical recommendations and recommendations for best practice for process safety management and risk assessment to a normalization institute with the aim of achieving standardization for industrial electrolyzers

Credible Hazard scenarios

- In the second hydrogen safety project we will conduct in-depth exploration, e.g. scenario's for:
  - In equipment mixing of H2 and O2
  - Loss of containment of H2 (in building)

Conclusion

- At the moment conservative design
- Working on standardisation of green hydrogen electrolyser safety
- Contributing to a more sustainable industry


Any
Questions