Safety aspects on ammonia power systems

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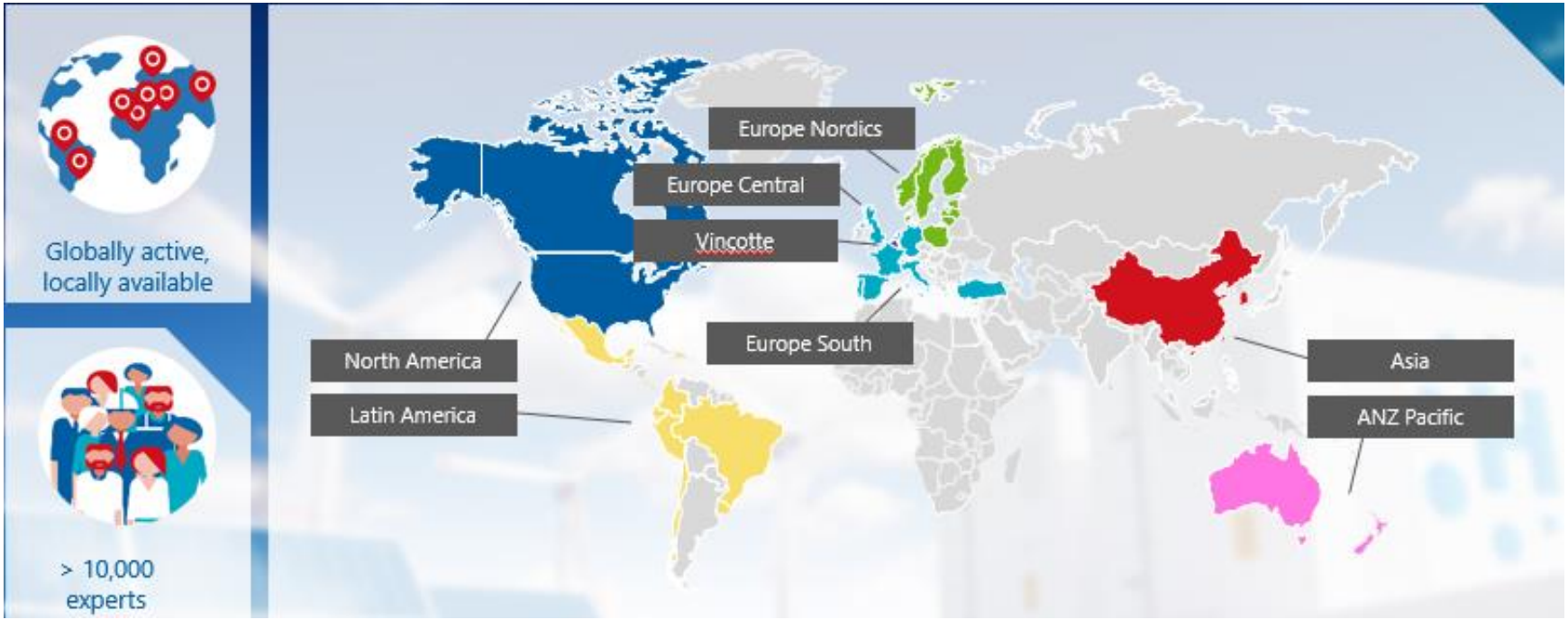
Outline

- Kiwa introduction
- Ammonia: perpectives for power sector
- AMON project - Ammonia use in power systems
- Ammonia: properties and associated hazards
- Procedure for certification of power systems
- Standards and literature
- Kiwa contribution to standarisation
- Open discussion: Q&As

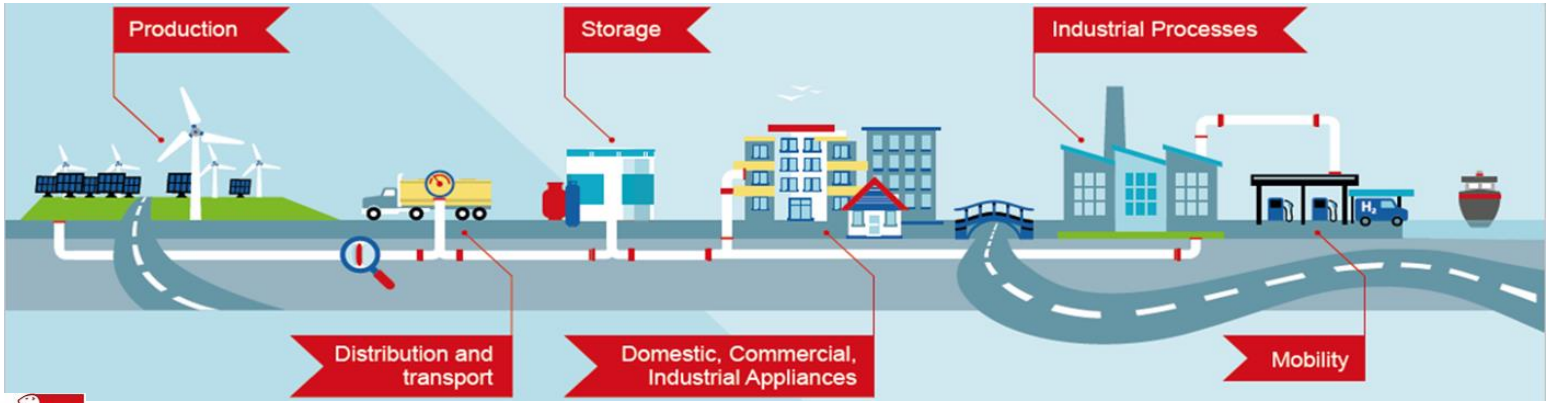
Kiwa Introduction

Who we are / Locations



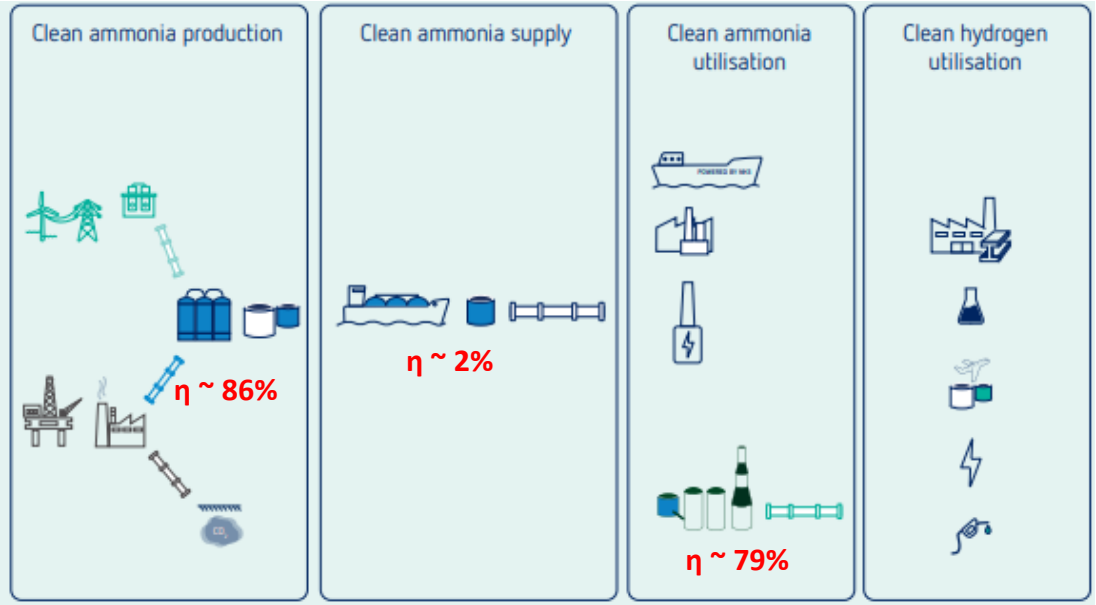
Kiwa Introduction

What we do / sector services



Ammonia in the power sector

Ammonia chain – from production to end use



Adopted from: "*Clean Ammonia RoadMap – Public Report*; Gijs Tubben, Hans van 't Noordende, Kevin H. R. Rouwenhorst, Marthe Fruytier; Institute for Sustainable Process Technology (ISPT); January 3, 2024; https://ispt.eu/publications/clean-ammonia-roadmap-public-report/"

Round trip :
η ~ 67%

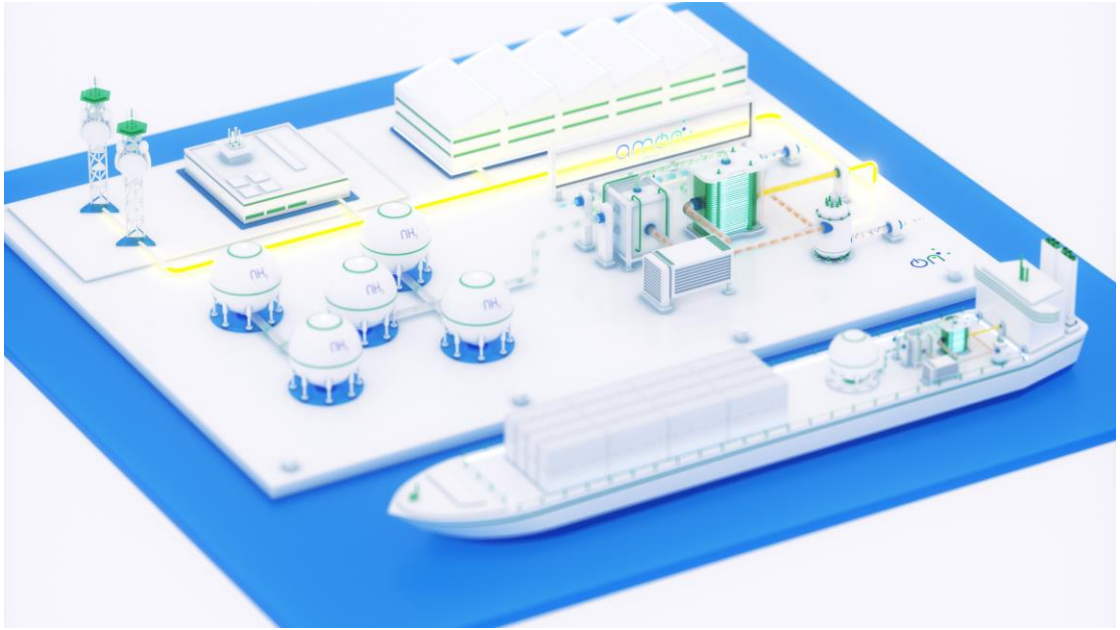
But it is much lower!!

Two main key factors for improving efficiency:

- Technological innovation
- Reduce the number of processes in the chain

AMON project - Ammonia use in power systems

Direct conversion of ammonia into electricity in a fuel cell power system

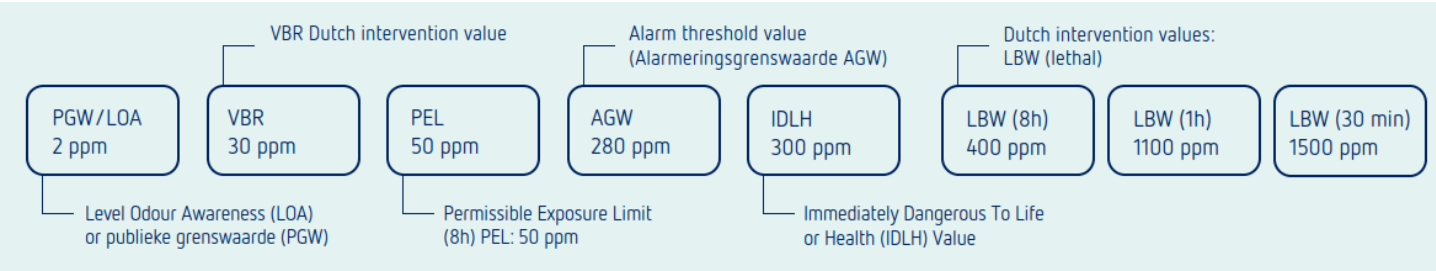


Target:

- Increase the energy efficiency of the chain
- Decarbonization of maritime sector
- Safety concept

Ammonia – Properties and hazards

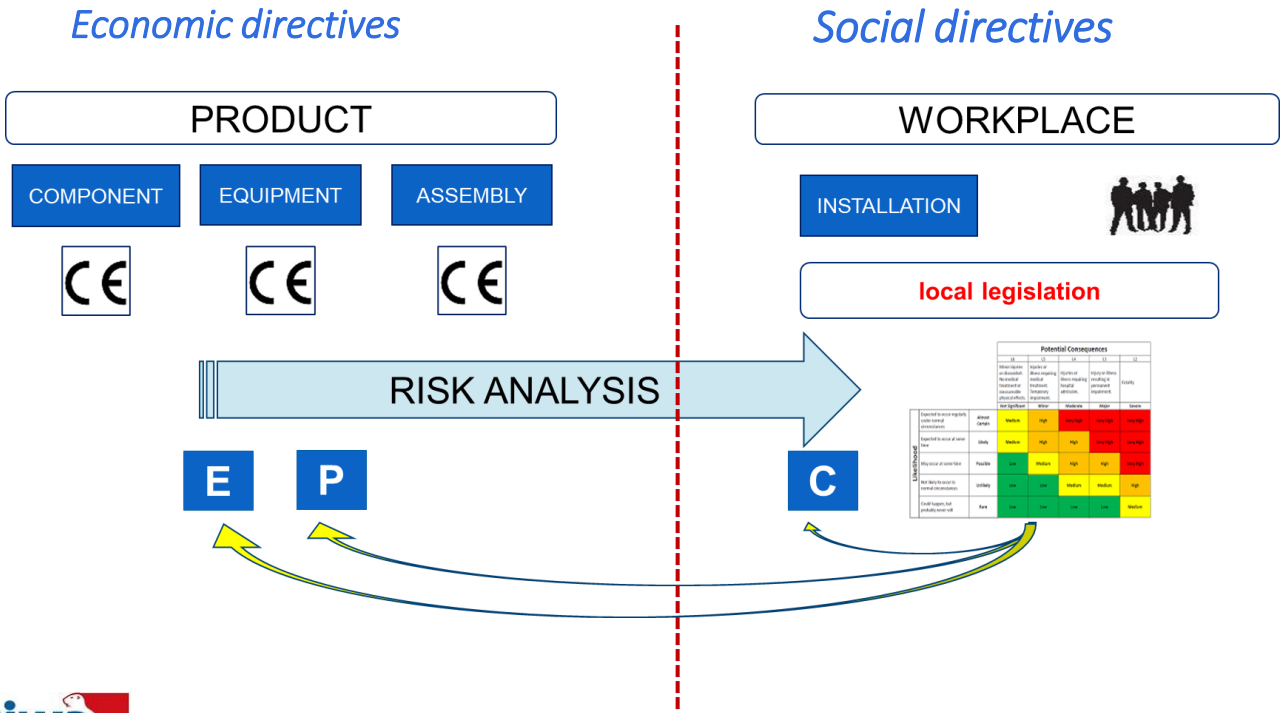
- Health treaten for human beings
- Ammonia is a non- explosive (highly) and not high flammable
- Very tansparent and low speed flame
- Very toxic for aquatic organisms, the soil and air
- Chemically unstable at high temperatures (nitriding)
- NOx emissions



There is a need for regulations and updated standards for the entire value chain of ammonia!!!

Procedure for certification of installation of power systems

Economic vs. Social directives



How to comply with directives:

- Harmonised standards
- European standards
- International standards
- Other rationale

Procedure for certification of power systems

Certification process in a nutshell

Pre-Assessment (Design Phase)

- Initial Workshop/s
- Gas safety assessment
- Review of the risk assessment
- Design Review
- Identification of all applicable directives and relevant standards

Costructional Review (Prototype phase)

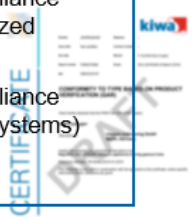
- Verification if components and system meet general requirements of the product standard ISO 22734, EN 62282, EN 50465
- Test program identification
- Assessment of the functional safety

Type Testing (Prototype phase)

- Tests at Kiwa facilities or at client's site in witness
- ISO 17025 accredited tests

Certificate(s) (Production phase)

- Certificate" of presumption of conformity with ISO 22734 or EN 62282
- Certificate of compliance with PED (pressurized systems)
- Certificate of compliance with GAR (µCHP systems)
- Others



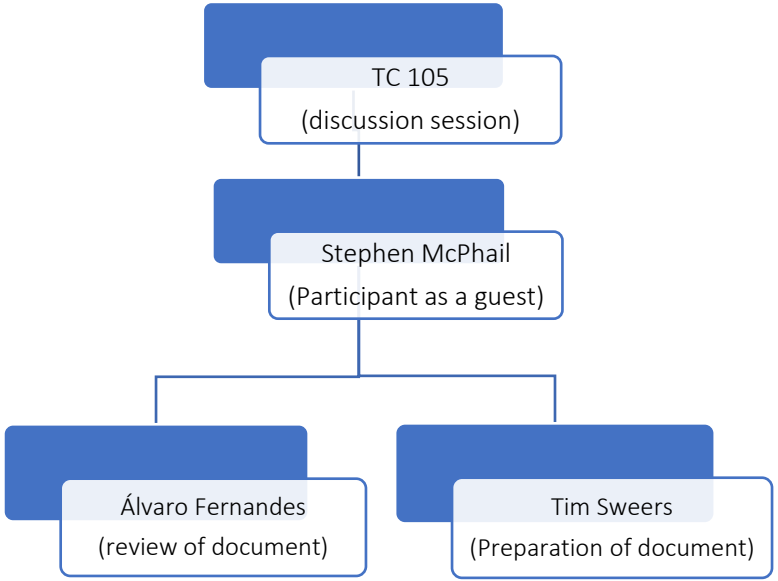
Standards and literature

- Ammonia is not regarded as a fuel
  - IEC 62282-3-100 Fuel cell technologies - Part 3-100: Stationary fuel cell power systems – Safety
  - H2 and hydrocarbons as fuel are in the scope, but not ammonia
- There is very little information available on literature
  - Suitable materials for high temperature operation
  - Best practices of use of ammonia in power systems
  - Practices on other technologies (heat pumps, refrigeration systems)

Kiwa contribution to standarisation

Standards

- IEC 62282-3-100 Fuel cell technologies - Part 3-100: Stationary fuel cell power systems – Safety
- Standards on guideline on materials for ammonia
- Standards on best practices of the use of ammonia in power systems
- Document: “Outline of hazards for inclusion of ammonia”

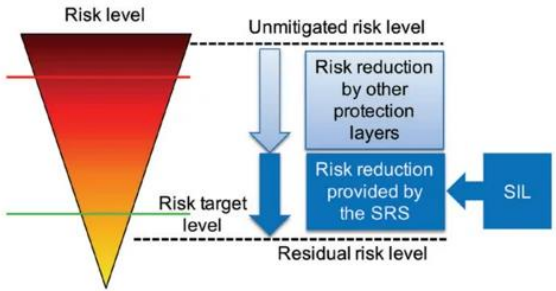


Kiwa contribution to standarisation

Inclusion of ammonia in IEC 62282-3-100

Residential, commercial and light industrial	(Light) and large industrial
Ordinary people and domestic animals	Trained personnel
Functional safety: deterministic method The death of a person or animal is not acceptable Class A - not intented for safety Class B – Immune to single fault Class C – immune to double fault (fail safe)	Functional safety: reduction of risk (probablistic method) The risk is reduced to an “acceptable level”. Still the death of a person can occur. SIL requirement - 1, 2 ,3 and (4)

From: https://www.ors-consulting.com/what-is-sil-safety-integrity-level



From: https://insights.tuv.com/blog/what-you-need-to-know-about-functional-safety-assurance

Kiwa contribution to standarisation

Inclusion of ammonia in IEC 62282-3-100

- Content of document:
  - Risk assessment
  - Proposed modifications on the clauses:
    - Attention point: to materials for high temperature ammonia use
    - **Mandatory:** Limit emissions of ammonia to less than 0,02%
    - Attention point: for ammonia use in high humidity environment (fog formation, ammonia heavier than air)
    - Attention point: should not exceed 25 ppm concentration in low ventilation places (where ordinary people and domestic animals can access the installation place)
    - Annex: brief explanation of properties and characteristics of ammonia.
    - Installation of ammonia appliances inside of residential houses is not advisable

THANK YOU

more info www.amon-project.eu

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