FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

GrInHy2.0
Risk Assessment Approach
Workshop on Safety of Electrolysis

Alexander Wooning

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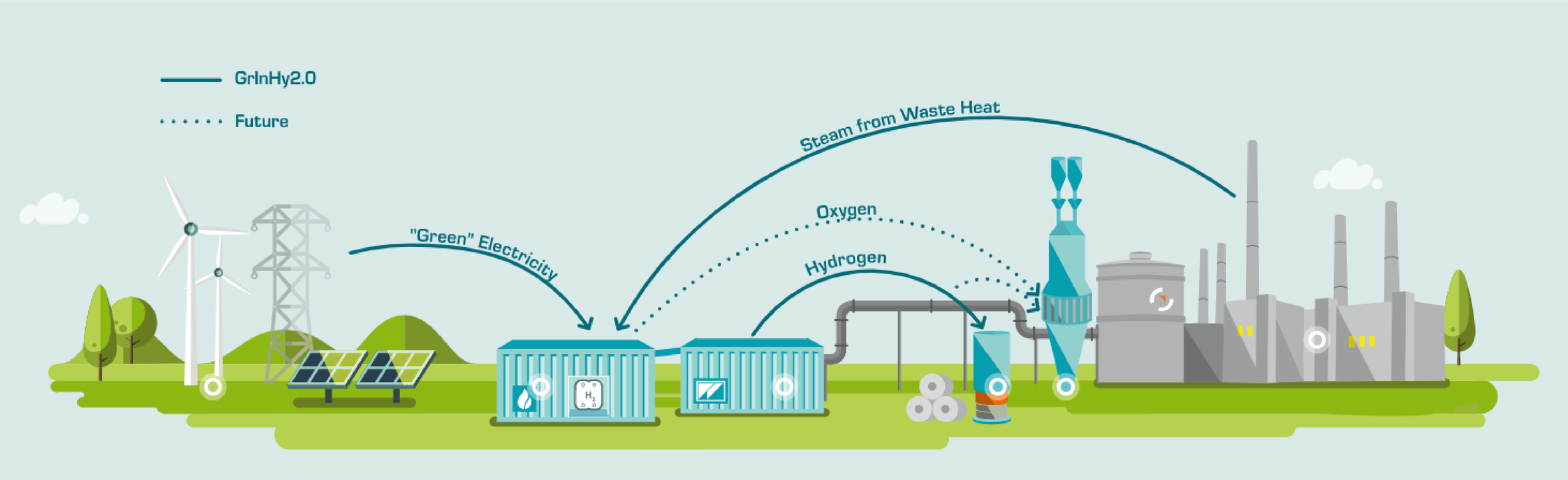
Project Brief



Project Partner

- **Sunfire GmbH**
  - Developer and provider of the SOF steam electrolyser (HTE)
  - Responsible for manufacturing, installation, operation and maintenance

- **Paul Wurth S.A.**
  - Developer and provider of gas processing technologies
  - Responsible for the design and development of the HPU

- **Salzgitter Flachstahl GmbH**
  - Site owner and operator of the iron-and-steel works
  - Responsible for the operation and production of green hydrogen

- **Salzgitter Mannesmann Forschung GmbH**
  - Centralized research and development (R&D)
  - Responsible for the overall project coordination and the full Life Cycle Assessment

Project Partner

- **Tenova S.a.P.**
  - Developer of innovative technologies and services for the metal and mining industries
  - Creates a study on the CO_2 avoidance potential of hydrogen in the European steel industry

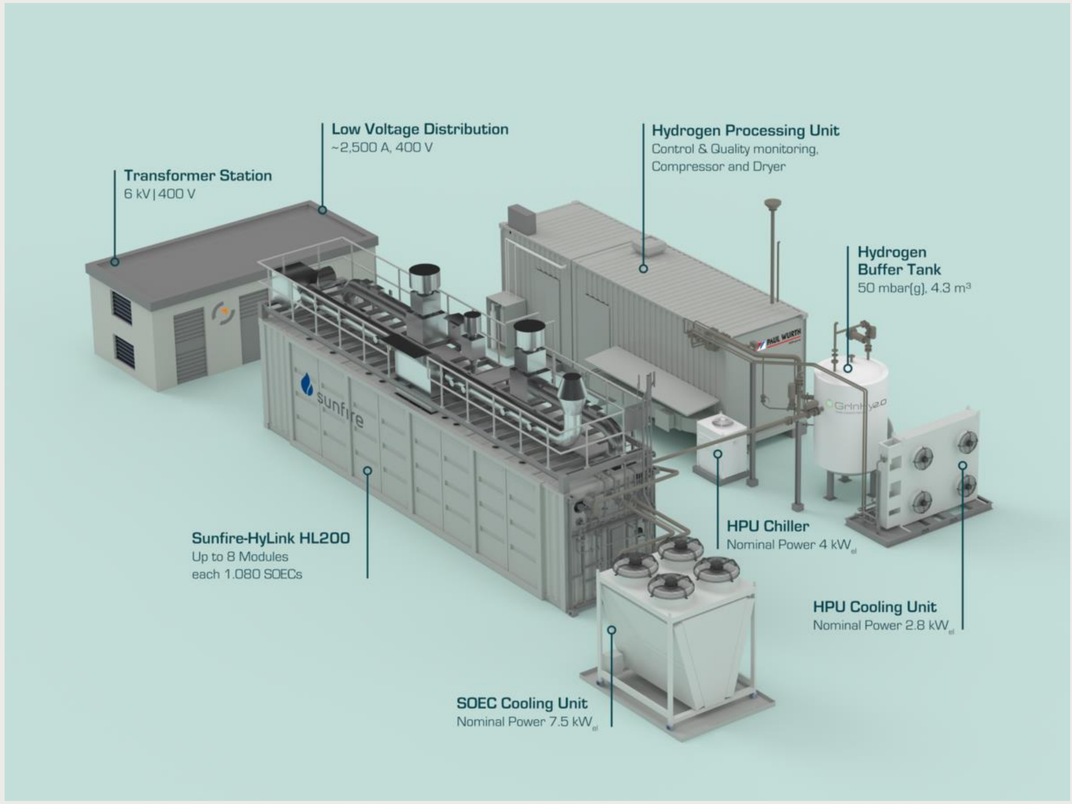
- **CEA - Commissariat à l'énergie atomique et aux énergies alternatives**
  - Key player in research, development and innovation
  - Provides long term stack tests as well as an energy management strategy assessment

Project Objectives

- **Technical:**
  - Electrolyser scale-up to 720 $kW_{el,AC}$ producing 200 Nm^3/h (18 kg/h)
  - Electrical electrolyser efficiency up to 84 $\%_{LHV}$
  - >13,000 operating hours at system level with a proved availability of >95 %
  - > 20,000 operating hours at stack level

- **Economical:**
  - Produce >100 tons of green hydrogen at under 7 €/kgH2
  - Reduce electrolyser CAPEX to <4,500 €/(kgH2/d)

- **Socio-political:**
  - Create viable technology by demonstration in a complex industrial environment
  - Assess CO_2 avoidance potential of a hydrogen-based European steel industry
  - Provide significant share of green hydrogen to the iron-and-steel works



Regulations, Codes and Standards

Directives:

- Directive 2014/35/EU - Low Voltage Directive (Full conformity assessment)
- Directive 2014/68/EU – Pressure Equipment Directive
- Directive 2014/30/EU - Electromagnetic Compatibility Directive
- Directive 2011/65/EU - RoHS Directive

Codes & Standards:

- DIN EN ISO 12100:2011-03; Safety of machinery - General principles for design - Risk assessment and risk reduction
- DIN EN ISO 13849-1:2016-06; Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
- DIN EN 60204-1:2019-06; Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- DIN EN IEC 61000-6-2:2019-11; Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
- DIN EN 61000-6-3:2011-09; Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments
- DIN EN 61511-1:2019-02; Functional safety - Safety instrumented systems for the process industry sector
- ISO 22734:2019-09; Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications

Risk Assessments – System Level

- **Phase 1: Risk Assessment Basis – ISO 22734**
  - ISO 22734:2019-09 - Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications
  - Covers general design rules for electrolyser to cover general risks and hazards

- **Phase 2: Individual project specific Risk Assessment**
  - Identifying risks that are not a result of abnormal operational conditions during all life phases

- **Phase 3: HAZOP**
  - Identifying and assessing risks induced by abnormal operational occurrences during all operational states

Prevention and mitigation – ATEX hazard mitigation

Normal Operation:

- Hydrogen containing pipes are technically tight
- Ambient pressure operation results in very small potential leakage rates
- Gas-space around the stacks is equipped with a temperature safeguard, which prevents entering burnable gases below the ignition temperature
- Gas sensors are used as additional safeguards
- All pipes and sensors are inspected and maintained on a regular basis

Postulated Worst Case Incident: Cracked welding of H2 containing pipe

- **Design and Construction:** Full enclosure of the electrolyser with forced ventilation
  Exhaust of gases via roof result in ATEX Zone 2
  Ensure no ignition sources on top of electrolyser

- **Protective Measures:** If gas sensors detect high elevated concentration shut down is immediately initiated

- **Information /Organizational countermeasures:** No personnel allowed on top of electrolyser during operation
  Warning signs, operational instruction, and training of personnel

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Alexander Wooning
Safety Engineer
Alexander.Wooning@sunfire.de

For further information
www.fch.europa.eu

@fch_ju

Fch-ju@fch.europa.eu

FCH JU