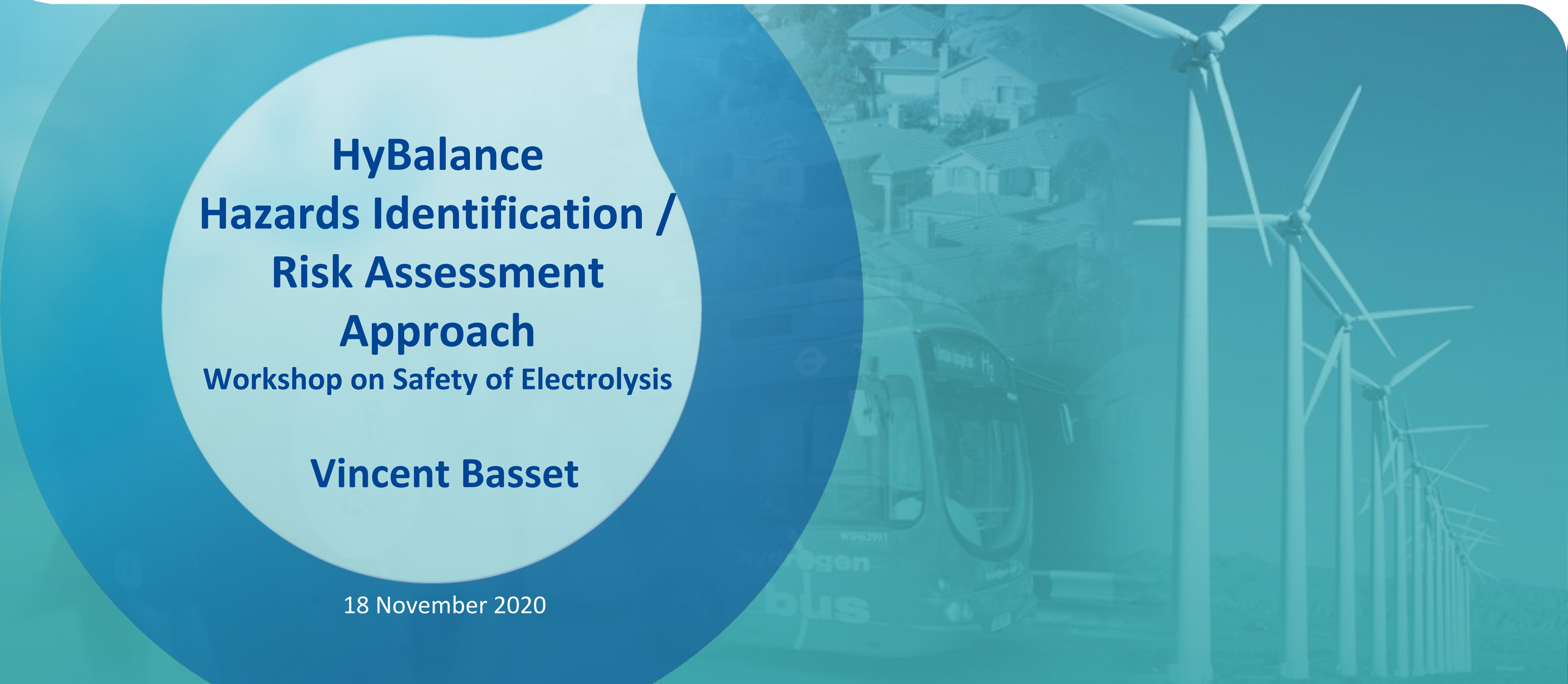
FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

HyBalance Hazards Identification / Risk Assessment Approach

Workshop on Safety of Electrolysis

Vincent Basset

18 November 2020



HyBalance

Workshop on Safety of Electrolysis

Project Brief

- Consortium

- Total project budget: **15 M€**

- FCH JU max. contribution: **8 M€**

- Danish Contribution: **2,6 M€**

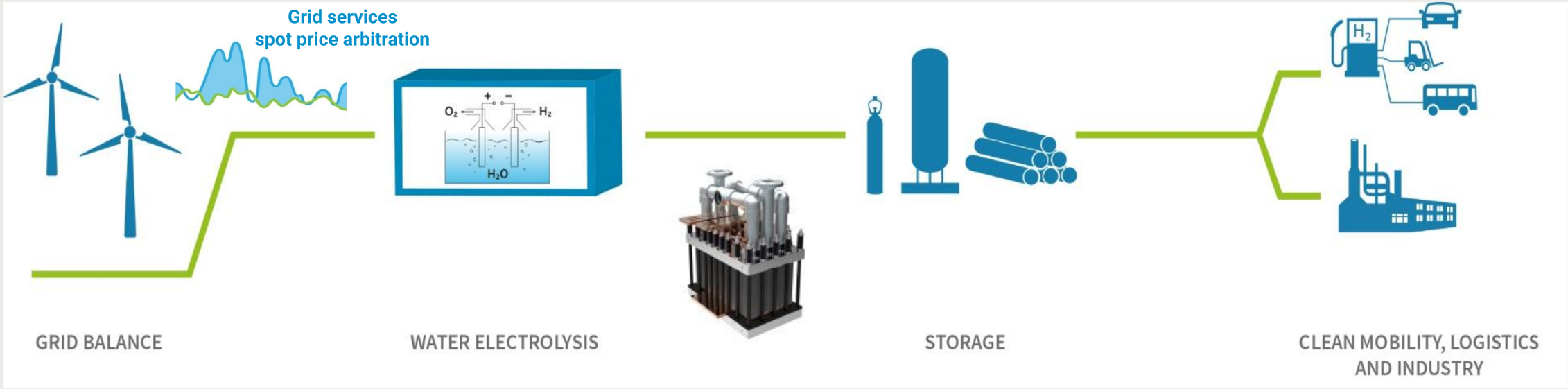
- Program dates: from October 2015 to September 2020 / Plant start-up in February 2018

HyBalance

Workshop on Safety of Electrolysis

Main achievements

- Implement the production and supply chain of **low carbon H2** : tube trailer filling and customer supply by a pipeline
- Demonstrate the performance of **PEM** electrolysis technology for grid balancing services
- Enable the storage of renewable electricity from wind turbines - - - > **Power to H2**



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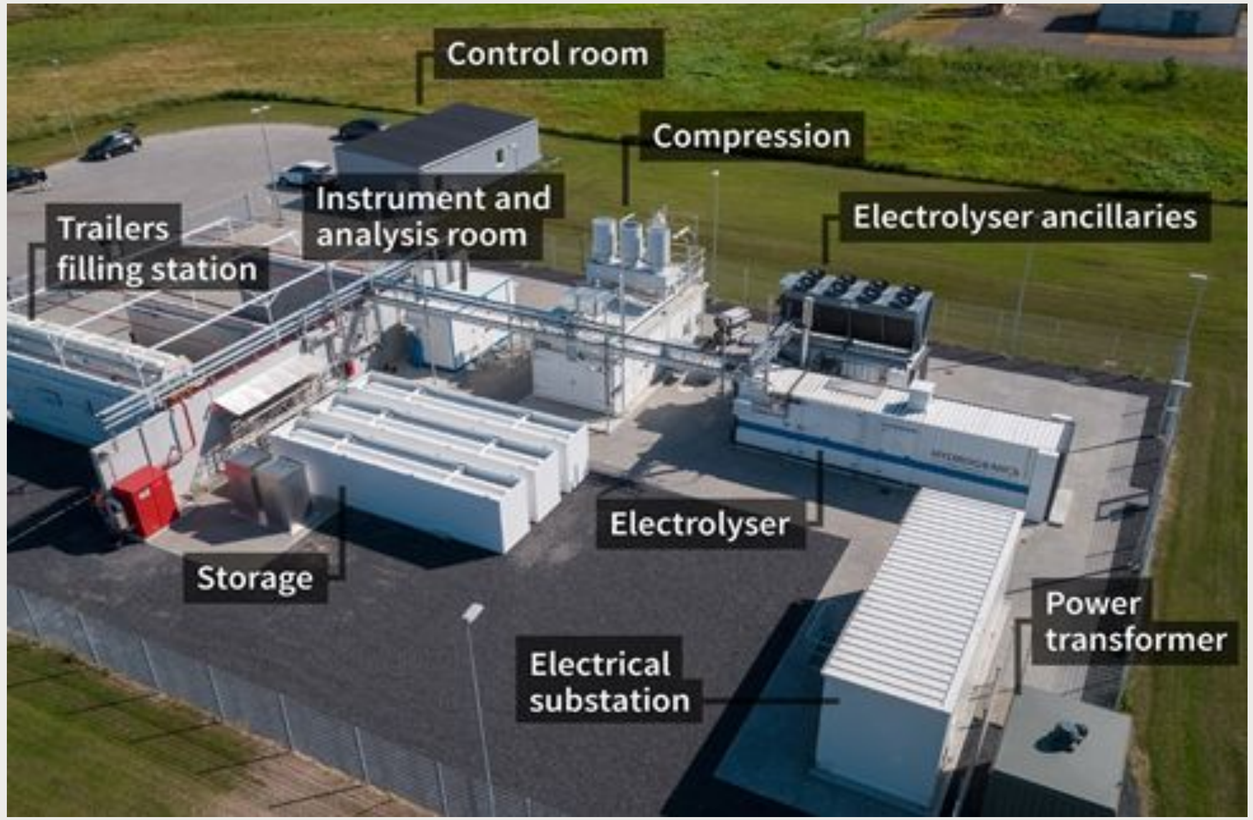
Site Location in Hobro, Denmark



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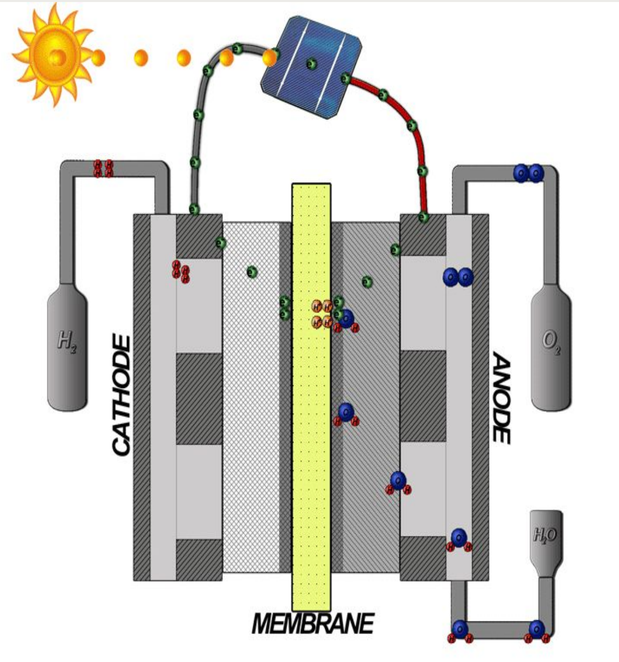
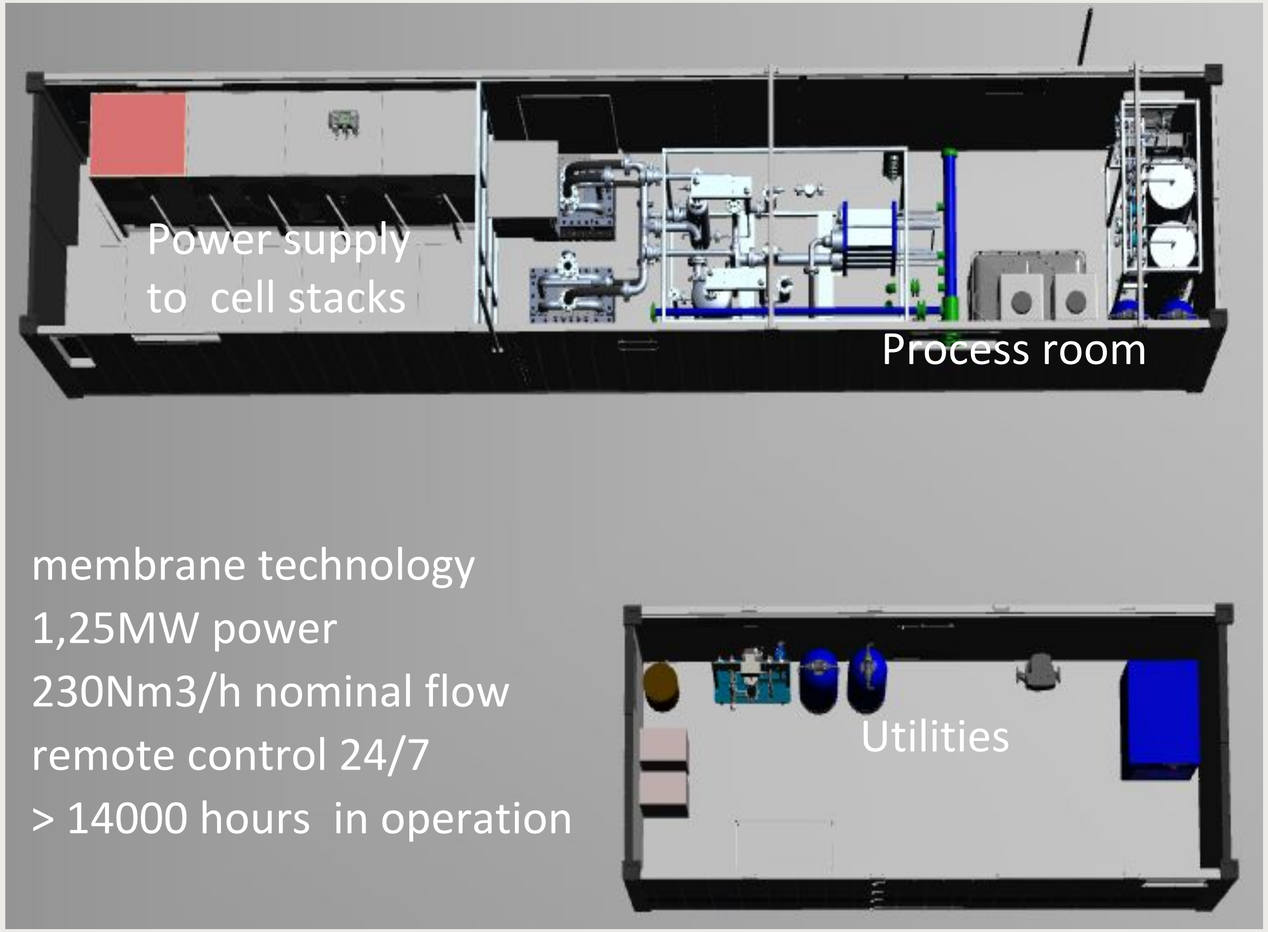
PEM Electrolyzer main characteristics





Regulations, Codes and Standards

3 main specific regulation requirements applied to the hydrogen station :

- Environmental and building permit : lead by Air Liquid with the support of local contractor COWI. Environmental permit given by EPA, building permit by the municipality

- No specific regulation today in Denmark for H2. Use of Danish legislation on safety for gas equipment (from 21 April 2018 - Danish text Bekendtgørelse nr. 239 af 23. Marts 2018). H2 is mentioned in this law with specific requirements.

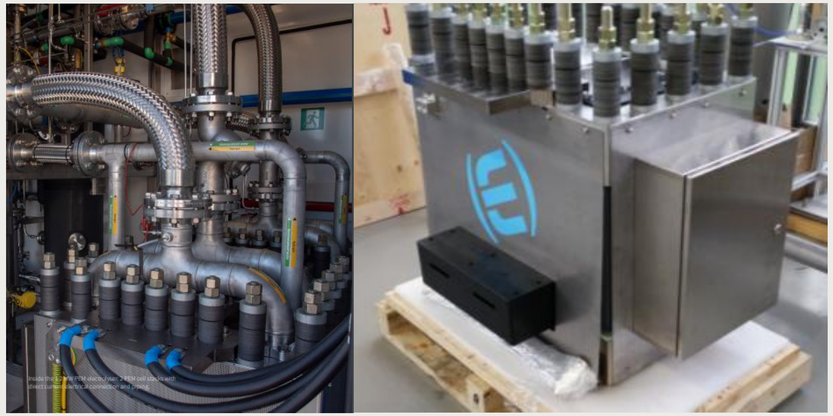
- Danish fire regulation : involvement of local fire brigade in order that the station comply with the fire regulation DEMA

- Other regulation are European ones (pressure, electrical, etc) but with local approvement by notified body or by the sub-contractor

Risk Assessments / Identification of main safety risks of the electrolyzer

Project Risk managements process

- from the HAZOP
- to the ARA (Air Liquid method - quantitative risk assessment)
- to EIS identification (final mitigation barrier which avoid a fatality)



Main safety risks identified

1. cross over of H2 in O2 line (flammable mixture) due to membrane failure
2. H2 - O2 mixture into the gas separator vessels
3. H2 or O2 or N2 external release inside the process room
4. Oxygen fire in process line due line uncleaned or to high gas velocity

Prevention and mitigation

1. **Cross over of H2 in O2 line due to membrane failure (i.e ageing)**
   - voltage continuous control
   - delta pressure control wired on electrolyzer safety shut down
   - H2 analyzer in O2 line
   - periodical replacement of the membranes

2. **H2 - O2 mixture into the gas separator vessels**
   - pressure safety valve (PSV) on each separator
   - high pressure sensor wired on electrolyzer safety shut down

3. H2 or O2 or N2 external release inside the process room

- H2 and O2 gas detection wired on electrolyzer safety shut down
- mechanical ventilation with electrolyzer stop in case of failure

4. Oxygen fire in process line due line uncleaned or to high gas velocity

- specific cleaning procedure after start-up or maintenance
- O2 velocity design compliant with EIGA 13/12/E recommendations

To conclude a short slide of the main safety risk on the station after the electrolyzer : external H2 leak / fire

H2 leak / fire located :

- in the compressor skid
- on the hydrogen high pressure storages in free area
- on the trailer's hydrogen filling ramp

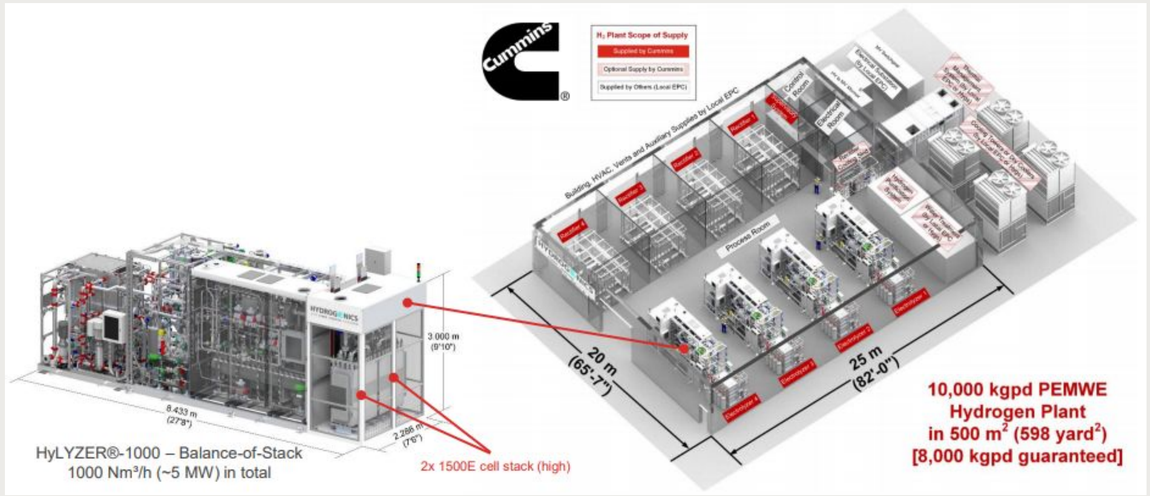
The main mitigation measures are:

- hydrogen / fire detection in the compressor skid
- hydrogen /fire detection up to the storages and filling panel
- casing (fences) around the storages to avoid fire jet on the cylinders
- acoustic meter
- water spray system up to the trailer filling area and separative wall

When not passive, all the barriers wired to the safety shutdown of the station/ valves interlocked

Lessons learnt and application for new H2 electrolyzer plant

- Through Hybalance project, Air Liquide managed to set the list of the main safety risks of a PEM electrolyzer
- Consequence : some upgrades of the electrolyzer design were introduced in order to ensure a deeper mastering of the process risks according to the AL rules
- NO major safety incident after quite 3 years of operation
- Experience feedback used for new PEM electrolyzer projects with higher power
  e.g. Becancour - Canada (20MW - 8000kg/day - in construction)



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