Electrolyser integration into a large green ammonia facility: potential hazards and mitigation strategies

Derek Miller

Process Safety Director,

Air Products

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Overview

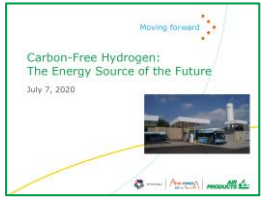
NEOM: World's Largest Carbon-free Hydrogen Project

NEOM, a new model for sustainable living located in the Kingdom of Saudi Arabia, is the site of a $7 billion project which will enable Air Products to supply carbon-free hydrogen to power buses and trucks around the world by 2025 and eliminate three million tons per year (TPY) of CO_2 emissions and smog-forming emissions and other pollutants from the equivalent of over 700,000 cars.

The joint venture project with NEOM and ACWA Power is based on proven, world-class technology and will include the innovative integration of over four gigawatts of renewable power from solar, wind and storage; production of 650 tons per day of hydrogen by electrolysis using thyssenkrupp technology through Air Products' exclusive strategic cooperation agreement; production of nitrogen by air separation using Air Products technology; and production of 1.2 million tons per year of carbon-free ammonia using Haldor Topsoe technology through Air Products' global alliance agreement.

https://www.airproducts.com/company/innovation/megaproject-expertise

AIR PRODUCTS



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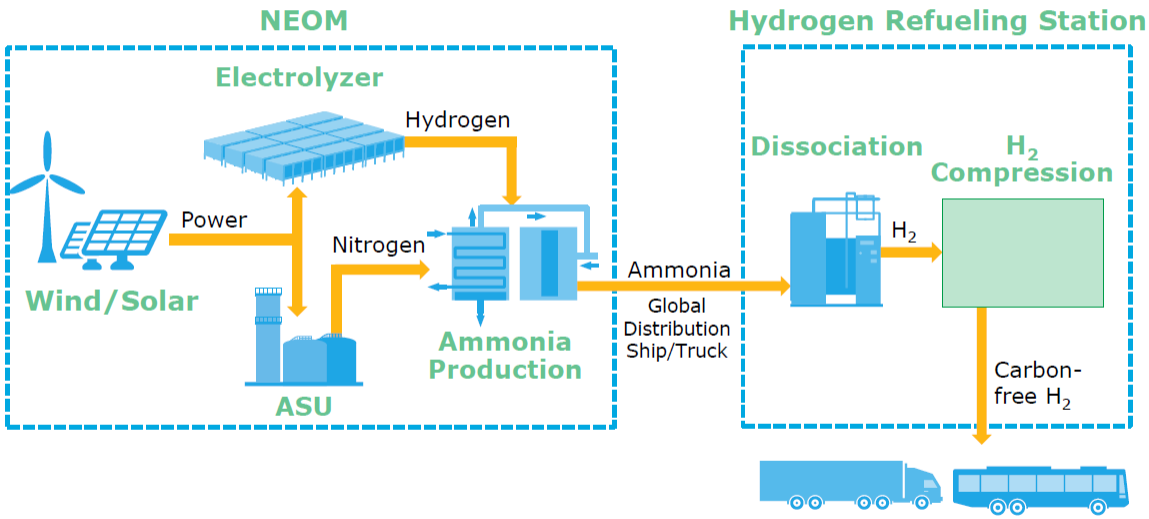
Moving forward

Carbon-free hydrogen

Produced and delivered with proven, world-class technology



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AIR PRODUCTS

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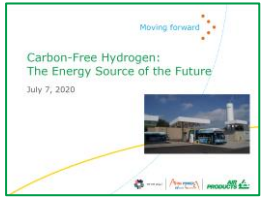

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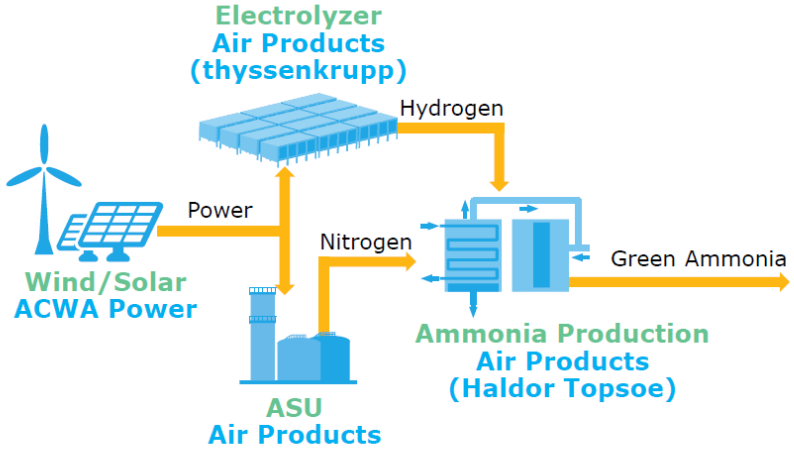
Moving forward

Carbon-free hydrogen

Produced with proven, world-class technology in NEOM, Saudi Arabia



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Electrolyser hazards include:

- H_2 / O_2 recombination
  - Always some transfer of gas between H_2 and O_2 streams
  - Electrolyte flow reduction increases potential accumulation
  - Voltage, temperatures, differential pressures, gas compositions: monitor, alarm, trip
- Caustic electrolyte
  - Personnel protection from leaks (shielding)
- Electrical safety
  - Exposed bus bars etc. mean hazard always present
  - Careful considerations on insulation & grounding of equipment, platforms etc.
  - Special precautions and training required for entry and work near cells
- Building atmosphere
  - H_2 leaks, fire or explosion risk
  - N_2 leaks, asphyxiation risk
  - Ventilation & inlet filtration
  - Atmospheric monitoring & building design

Integration : challenge of variable green power

- Constantly varying electrical power generation from wind and sun
  - Example: if there is low / no wind, at night there will be almost no green power at all
- Battery Energy Storage System (BESS) buffers electrical power variation… but cannot eliminate significant daily variations
  - BESS brings its own thermal runaway hazards with potential for flammable off-gas fire & explosion
- Limited additional grey power available for running facility in idle mode, cannot be used to make green H_2
- Remote power generation and single transmission line means occasional total loss of site power is a possibility

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H_2 production

- Electrolysers cycle throughout day, based on green power availability
  - Quick ramping, wide range of operation, including idling
  - Challenge maintaining safe H_2 and O_2 purities under all conditions
- Smoothing out supply of H_2 requires significant intermediate H_2 storage with associated hazards
  - impact on facility siting etc.
- Even failure modes of safety valves, such as vents, needs to be carefully considered in case of total site power loss

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NH_3 production

- Plant also cycles throughout the day. Unique challenge vs conventional plant
  - Quick ramping, wide range of operation, including idling
  - Advanced automatic process control
- Challenge controlling key process parameters at all times
- Potential increase in demand on safety systems etc.

Summary

- **Scale of operation** requires careful management of very large amounts of energy
- **Dynamics of green power** bring real challenges keeping everything safe during rapid ramping and large swings in production
- **Established Technologies** bring some different hazards to an ammonia production facility