Consequence Modelling – EnTranCe Electrolysis Units for HyDROHUB project

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OBJECTIVE

- To perform consequence modelling for EnTranCe electrolysis units and suggest which configuration is safe.

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Introduction

- Types of Electrolysers are used:
  - Alkaline Water Electrolyser
  - PEM Water Electrolyser
- Two Plot layouts are identified
  - Configuration 1 : both electrolysers in north-south direction and utilities north
  - Configuration 2 : east-west configuration; utilities east right
- Siting study of Electrolysis units.



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Assumptions and Scenarios Modelled

- Since the internals of the Electrolysis is not available, the siting of the electrolysis unit is performed based on hydrogen and oxygen vents.
- The study is carried out using Shell's Physical Effects modelling tool FRED v 6.2.
- All calculations are based on steady state release modelling.
- Default weather condition (D5 and F2) is used.
- In order to determine effects of explosion overpressure generated from deflagration, pressure decay is obtained from Dorofeev et al. (which is comparable to the BST (Baker-Strehlow-Tang)) detonation curves.
- Hydrogen venting rate is assumed to be same as hydrogen production rate, while oxygen venting rate is estimate from hydrogen production rate.
- Hydrogen and oxygen is vented from vent stack which is vertically oriented.

Scenarios Modelled

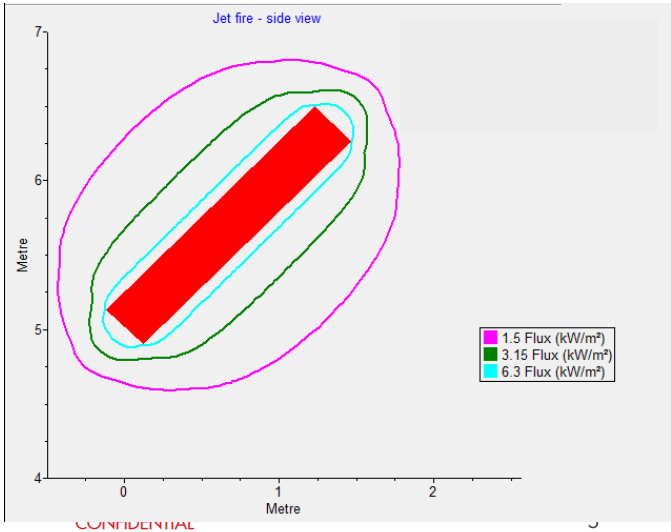
- Emergency venting of hydrogen at its maximum production rate.
- Continuous venting of oxygen at its maximum production rate.
- Delayed ignition (leading to vapour cloud explosion) hydrogen-air mixture formed inside the electrolysis unit.

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Hydrogen Consequence Modelling – Emergency Venting

- Hydrogen is a
  - highly flammable gas with wide range of flammability limits (4 – 76 %) and it has a potential to form a large flammable gas cloud.
  - In case of immediate ignition jet fire is produced while delayed ignition can lead to vapour cloud explosion which has the potential to generate overpressures high enough to impair the buildings.
- In case of hydrogen gas released from the hydrogen vent, the maximum extent of the flammable gas cloud is ~2 m (4 % LFL).
- In case of immediate ignition, the maximum extent of the heat flux (3.15 kW/m^2) reaches up to a distance of ~1.6 m.
- In case of delayed ignition, there is a possibility of deflagration of flame leading to generation of overpressure. Since the plume volume is quite low, therefore the overpressure generated is not high hence VCE calculations are not performed.



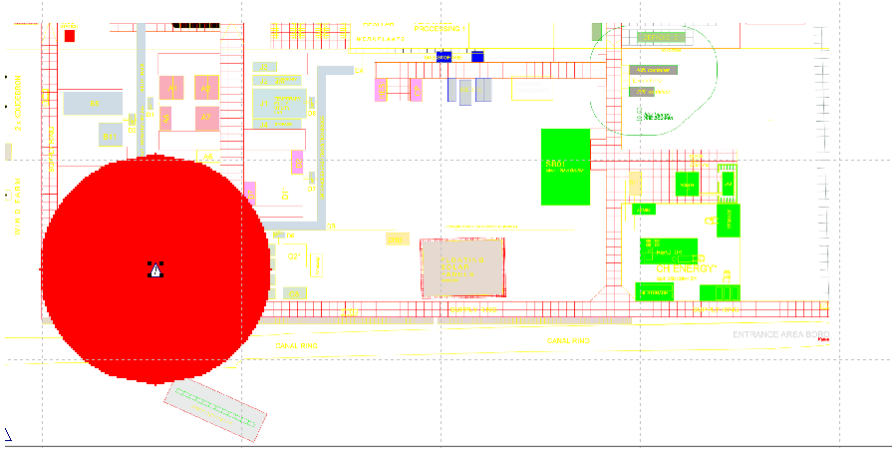


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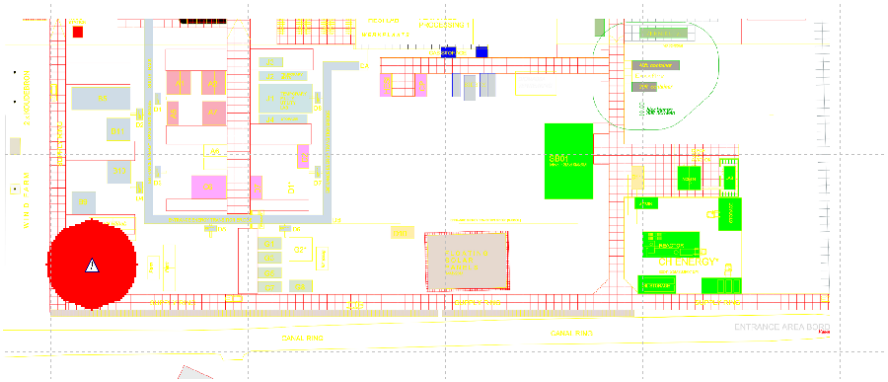
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Vapour Cloud Explosion Modelling – Configuration A

- Typically within the electrolysis unit, there are number of safeguards available to limit the formation of hydrogen-air mixture or reduce the likelihood of ignition of hydrogen-air mixtures.
- These safeguards are hydrogen gas detectors, natural and/or forced ventilation hazardous area classification and purging with nitrogen etc.
- Since it is not clear what safeguards are available, it is therefore assumed that these safeguards are not present in these electrolysis unit at this stage of the project.
- Vapour cloud explosion modelling was performed assuming inventory of hydrogen available with electrolysis unit and it is also assumed that it mixes with sufficient air to form stoichiometric hydrogen-air gas cloud.
- This clearly shows that small contour would be obtained for AWE than PEM. The contour corresponds to the distance to 70 mbar, the threshold value above which people would be impacted by an overpressure. For PEM this distance is 58 m, while for AWE it is 23 m.
- Note that different criteria would be applied for building damage e.g. 100 mbar (repairable damage) and 340 mbar (heavy damage).
- Distance to 100 mbar for PEM electrolysis unit is 44.7 m, while for AWE this distance is 17.9 m.



PEM – Configuration A



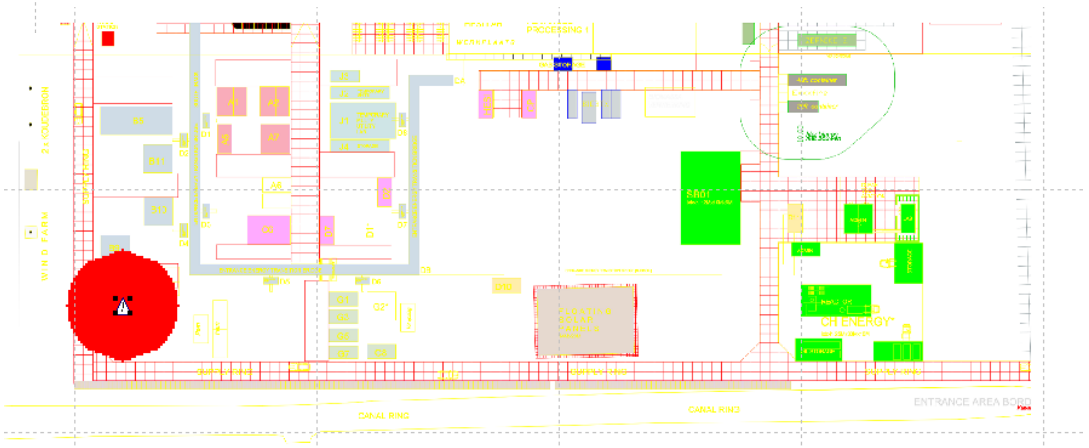
AWE – Configuration A

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Vapour Cloud Explosion Modelling – Configuration B



- PEM – Configuration B (Distance to 70 mbar)

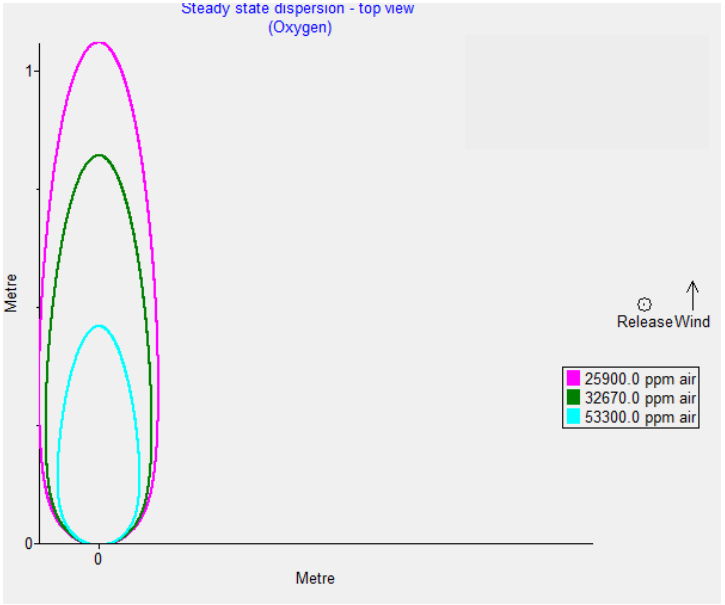


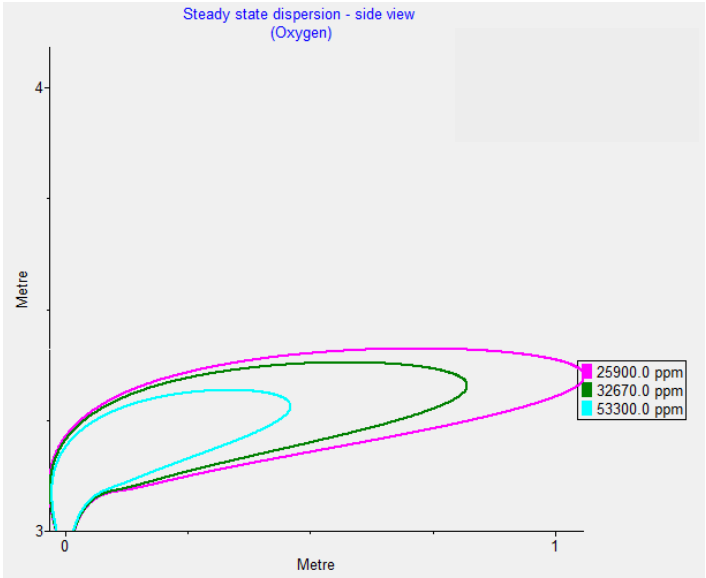
- AWE – Configuration B (Distance to 70 mbar

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Oxygen Consequence Modelling – Continuous Venting

- Unlike hydrogen, oxygen is not flammable gas, however,
  - enhanced oxygen level in the air can lead to breathing difficulties and even fatality.
  - there is an enhanced risk of fire at high oxygen concentration.
- It can be concluded that the oxygen concentration of up to 23.5 % can reach the radius of ~1.2 m from the oxygen vent stack.





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Conclusion

- It can be concluded that distance is dominated by vapour cloud explosion rather by dispersion and jet fire from hydrogen vents.
- The distance to 70 mbar is ~58 m in case of PEM electrolysis unit in comparison to AWE electrolysis unit (distance is 23 m.) This is because vapour cloud explosion is driven by hydrogen inventory present inside the electrolysis unit.
- It is suggested to use configuration B since PEM electrolysis unit is in the corner and away from the rest of the building.
- It is strongly recommended to revisit this study when more information about safeguards are available. Based on this further mitigation measures can be discussed.

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