Risk assessment of the potential for hydrogen to leak from geological store.

- A risk assessment of three geological scenarios was carried out using ISO 31000
- This involved a construction of a features, events and processes database and explanations of their contribution towards leakage
- 7 categories of potential hydrogen leakage pathways from 3 types of geological store were thus included in the FEP Database
- The goal was to identify high impact / high uncertainty risks based on these factors
- 12 cohort members from University of Edinburgh were invited to assess the risks and a review was conducted
- Monitoring and mitigation strategies from other technologies were then applied to the highest impact and uncertainty risks and adapted for hydrogen storage

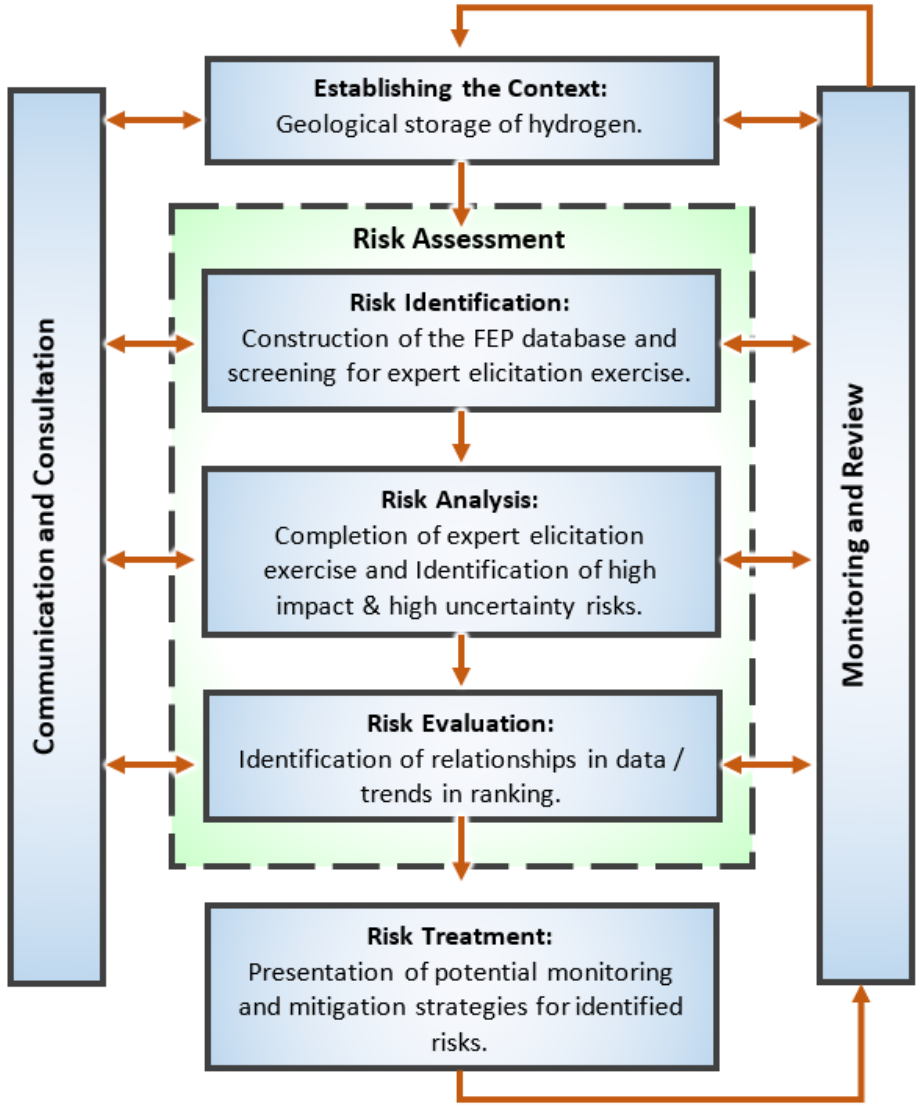


Figure 1.0 Risk Assessment process from ISO 31000 adapted to reflect project tasks.

Contact: Gabriellafuentes@hotmail.co.uk

Results: Impact and Uncertainty Risk Ranking

- There were 4 high impact & high uncertainty risks that could contribute to hydrogen leakage
- Salt Caverns had the lowest impact ranking but greatest uncertainty range of the 3 geological scenarios
- Depleted Gas Reservoirs / Porous Aquifers carried higher ranking impact risks but lower uncertainty range.
- Chemical risks were consistently ranked lowly in impact & uncertainty by experts across 3 scenarios.
- Wellbore and drilling environment and stress / faulting risks were consistently ranked high in impact and uncertainty across 3 scenarios.

Table 1.0 The presence of the highest ranked risks across the three geological categories.

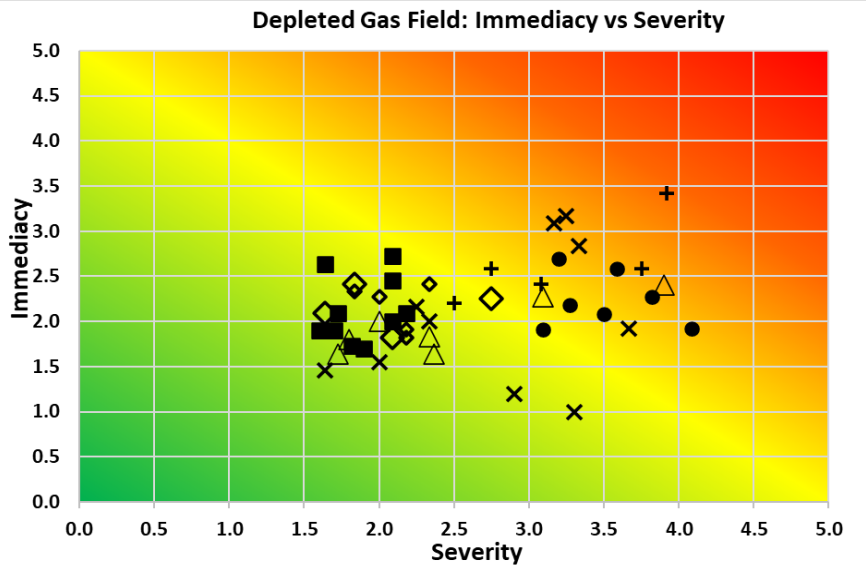
		Depleted Gas Reservoir		Porous Aquifers		Salt Caverns	
Highest Ranking Risks		High Impact	High Uncertainty	High Impact	High Uncertainty	High Impact	High Uncertainty
1	Equipment Malfunction	X	X	X	X	X	X
2	Human Error/ Miscalculations	X	X	X	X	X	X
3	Multiple Well Drilling	X	X	X	X	X	X
4	Well Sealing	X	X	X	X	X	X
5	Fracture Density / Geometry	X	X	X	X	X	
6	Well Blowout	X	X	X	X	X	
7	Induced Fracturing (Matrix)	X	X	X	X		X
8	Faults / Undetected Features (Over / Underburden)	X	X	X		X	X
9	Caprock Thickness	X	X	X	X		
10	Pressure Changes of Gas	X		X	X	X	

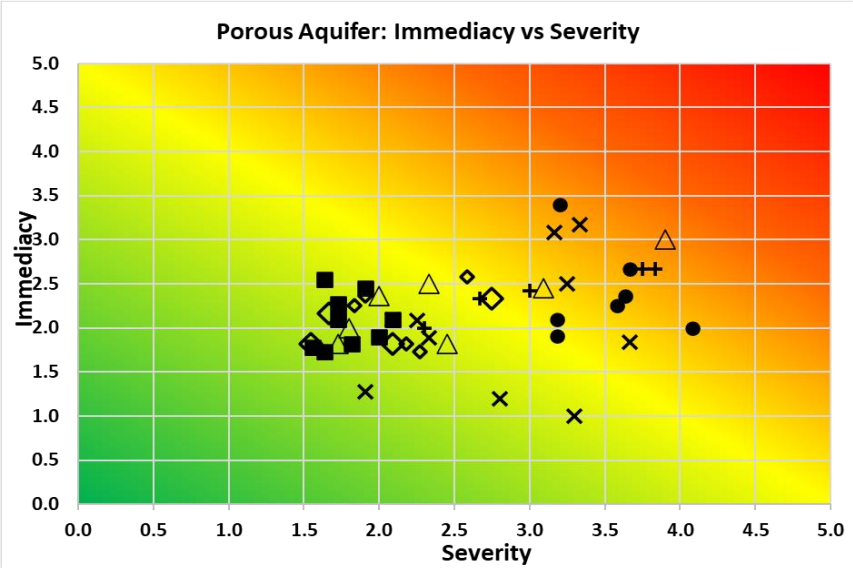
Table 2.0 Colour coordination of the categories included within the elicitation exercise and FEP database.

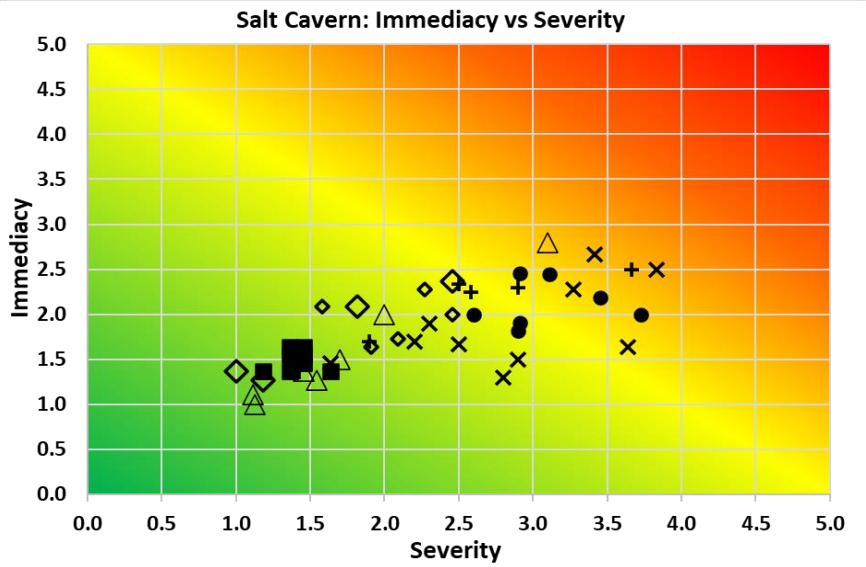
Chemistry	Gas Properties	Stress / Faulting	Geological Architecture	Wellbore and Drilling Environment	Events	Processes

Contact: Gabriellafuentes@hotmail.co.uk

Discussion: Impact & Uncertainty.







Key

- ◇ Gas Properties
- △ Geological Architecture
- ✕ Events
- ■ Chemical Properties
- ● Stress / Fracturing
- \+ Wellbore and Drilling Environment
- ◇ Processes

- Increase in severity values the highest immediacy value, 5, corresponds to leakage during injection (high immediacy)
- Expert opinion concludes that hydrogen leakage is most likely to occur during injection and early stages of storage operation
- The dispersion of risk categories across the 3 geological scenarios suggests that experts recognize that some risks take time to develop (e.g. chemical reactions)

Figure 3.0 , 5.0, 6.0: Matrix plots for Immediacy vs Severity for DGRs, PAs and SCs.

Contact: Gabriellafuentes@hotmail.co.uk

Summary

- Hydrogen is a challenging substance to contain in comparison to natural gas and CO^2 and so it security in the subsurface must be ensured to aid in the energy transition help achieve reaching net 0 by 2050
- It is import to carry out early risk assessment to secure environmental and economic safety in developing technologies
- Results of the study are consistent with other projects using this risk assessment method including CCS, hydraulic fracturing, nuclear waste disposal
- Results depict Salt Caverns as carrying the greatest uncertainty yet lowest impact risks
- Experts believe that high impact / high uncertainty risks are most likely to be unplanned events or faults in wellbore / drilling environment causing hydrogen leakage
- Risks consistently ranked as low impact / low uncertainty risks were considered for de- risking as due to low immediacy vs severity and confidence in cohort knowledge.
- Methods for monitoring and preventing leakage of hydrogen from geological store have been drawn on from other technologies and their suitability for hydrogen storage was considered

Contact: Gabriellafuentes@hotmail.co.uk