NET ZERO ENERGY

Rathrush Green Energy Park

Hydrogen-based Long Duration Energy Storage Solution

For Hydrogen Ireland

November 2026

www.netzeroenergy.ie

Agenda

1. Security of Supply/ Energy Sovereignty
2. System cost and optimised system
3. Role for LDES/multi-day in the power system
4. Rathrush Green Energy Project
5. Discussion & Questions



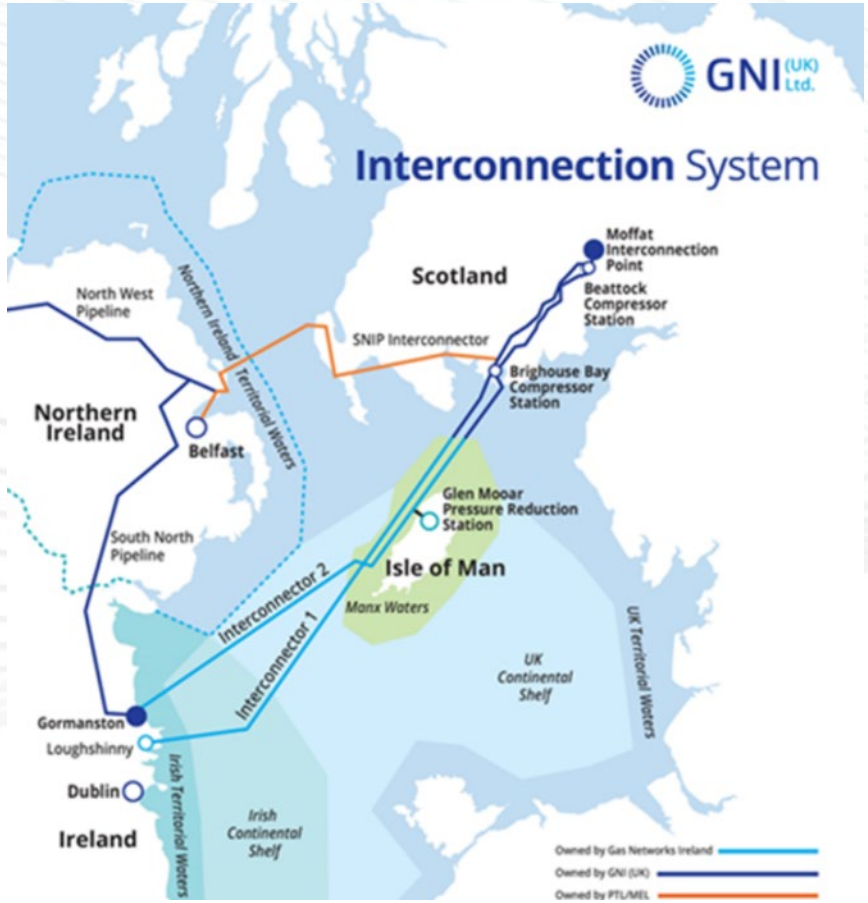
Kellis 220/110kV substation

Introduction to Net Zero Energy

- An Irish company developing the supporting projects that can get Ireland the last step to a 100% decarbonised and energy independent power system. We are focussed on the technologies that support the renewables.
- Our NZE (Net Zero Energy) team members each have over 20 years' experience in the Irish energy sector
- This team was central to a number of industry firsts, including:
  - Partnered with Statkraft to win contracts for four **sync-comps** in LCIS Phase 1, 2024 - currently in construction
  - 1st merchant interconnector (**Greenlink**, 2025)
  - 1st and 2nd grid-scale **battery** connected in Ireland (Kilathmoy, 2020 and Kelwin-2, 2021)
  - 1st demonstration site for synchronous compensator technology (Acres, Donegal, **2015**)
  - 1st use of Class 3 wind turbines in Ireland (Lisheen, 2009)
  - 1st V90 wind turbine order in the world (Kilgarvan, 2007)

Security of supply/ Energy Sovereignty

- Ireland has the **highest** fossil fuel import dependency of all major EU countries.
- Physically, with the Corrib gas field now nearly exhausted, and Kinsale decommissioned, Ireland is dangerously over-reliant on just two pipelines from Scotland for its gas.
- Ireland has seen 2 major energy price crises in the last 5 years
- Fossil fuel import costs jumped by **€6bn** in 2022, triggering high inflation[1]
- The Irish government spent around **€5.4bn** supporting households and industry during the Ukraine gas crisis[2]
- The repair time on a sub-sea pipe of this scale is 6 months.
- Ireland has 3-4 days backup liquid fuel at every power station.
- The FRSU at Cahiracon is necessary, but relies on regular LNG cargos



1. NESC Report on Fuel Imports.
2. https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices, government spend is from Sept 2021 to Jan 2023

Cost volatility



- Two gas price crises (10x and 3x typical price of €30/MWh) since 2020.
- Gas at €85/MWh in a CCGT at 50% capacity factor plus carbon at €90/t CO2 gives an electricity cost of €200/MWh.
- RESS bids have been clearing at €100/MWh.
- Our models suggest that the government target of 80% is pretty close to optimum even at a €30/MWh gas price.
- So one key reason Ireland has expensive electricity today is simply that we haven't built enough wind at half the cost of gas.
- Add in network, taxes, imperfections, dispatch down and supplier costs, and total cost is closer to €300/MWh, which is the c 30c/kWh on your bill.

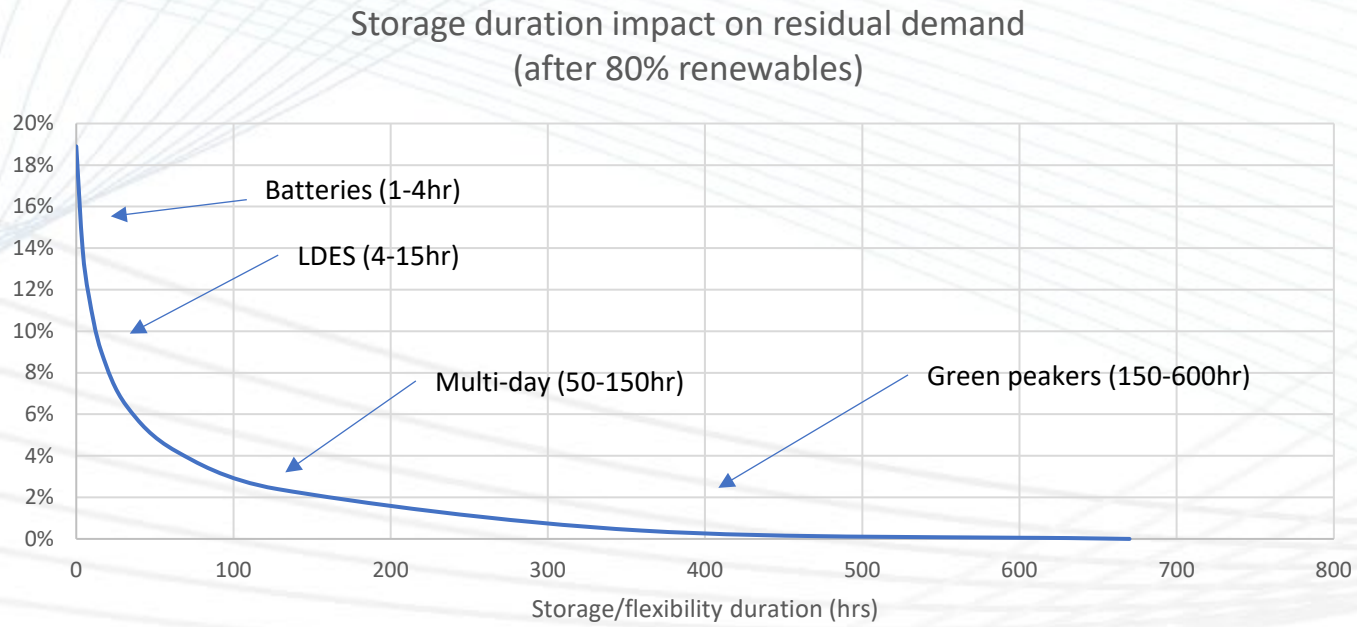
Finding the optimum system.

System Cost (€m/yr) (6GW peak in 2045)	Imported Gas Gas €30/MWh	Imported Gas Gas €80/MWh	RES & Storage No gas.
Onshore (GW)	14,400	14,400	14,400
Offshore (GW)	4,300	4,300	7,377
Solar (GW)	14,400	14,400	13,442
Li-Ion Battery (GW)	1,500	1,500	2,110
Multi-day (GW)	-	-	6,083
Green Peaking plant (GW)	-	-	2,613
Gas plant CCS (GW)	7,108	7,108	-
Gas peaker (GW)	3,200	3,200	-
RES-E%	78%	78%	104%
Oversupply	15%	15%	3%
CO2 ('000 t/yr)	1,300	1,300	-
Cost (€bn/yr)	-	+ €2.5bn	- €0.7bn

- System models find least cost in every hour, and the least cost generation mix.
- Tested over 40 years of weather.
- We did model interconnectors, but not individual 110kV lines
- Conventional wisdom is that variability of renewables can only be balanced with gas.
- But with enough of the right storage, you don't need gas.
- This achieves "Energy Sovereignty", meaning Ireland has full control over the sources of energy in its electricity system.
- A system using storage is cheaper, lower carbon and nearly eliminates dispatch down.

Multi-day storage in a secure, net zero system

- If Ireland builds 7/8/9GW of renewables, it will achieve (optimum) 80% RES-E target.
- But this will result in a c.40% surplus, and c.20% deficit (residual demand).
- Storage can move the surplus to the deficit.
- Renewables deployment has got ahead of the necessary flex and storage. The PSO will balloon without storage. Ireland could end up discarding c.35% of its wind early in 2030s.



Low/zero capacity value	→	High capacity value
Medium utilisation	→	Very Low utilisation
Mid-merit	→	Peaker
Medium decarbonisation	→	Low decarbonisation

High Level Policy

Hydrogen Strategy - July 2023

- Hydrogen for zero carbon power generation and long duration storage is **Priority 2 of 11** in this strategy
- Recognises need for early development works and technology demonstration projects and will provide Innovation Funding for these projects
- Range of **2-4TWh/yr** of renewable gas (incl. H_2) anticipated

Electricity Storage Policy Framework - 2024

- Target 'to ensure a route to market for the identified optimum (**long duration**) electricity storage requirements for 2030-2040 is in place before end of 2028'

Energy Security In Ireland to 2030

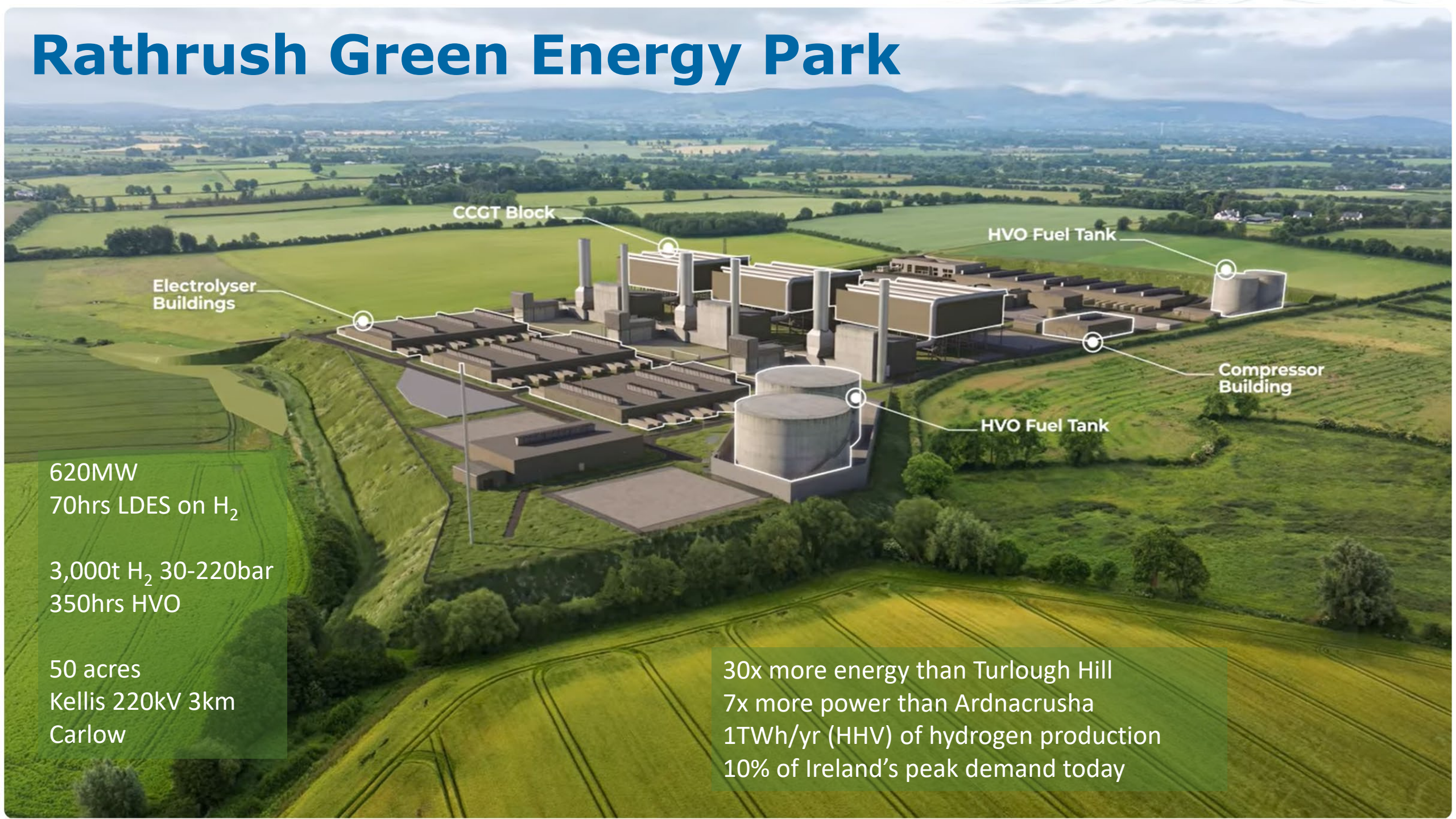
- Focus on renewables, reducing reliance on fossil gas, and **long duration energy storage** to achieve energy independence in the medium term (but with FSRU in the interim).

Table 7: Summary of hydrogen end uses envisioned

End Uses	Priority Order	Role Envisioned	Alternative Technologies	Likely market entry timeframe
Existing hydrogen end users	1	Renewable hydrogen to replace the niche fossil fuel-based hydrogen uses currently in Ireland	N/A	2025-2030
Flexible Power Generation and long duration energy storage	2	Zero carbon flexible backup generation and long duration energy, enabling high penetrations of variable renewables and system security	Bioenergy-based generation, CCS enabled natural gas generation, system flexibilities (demand side management. etc.)	2030-2035

p.21 https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/national-hydrogen-strategy/

Rathrush Green Energy Park

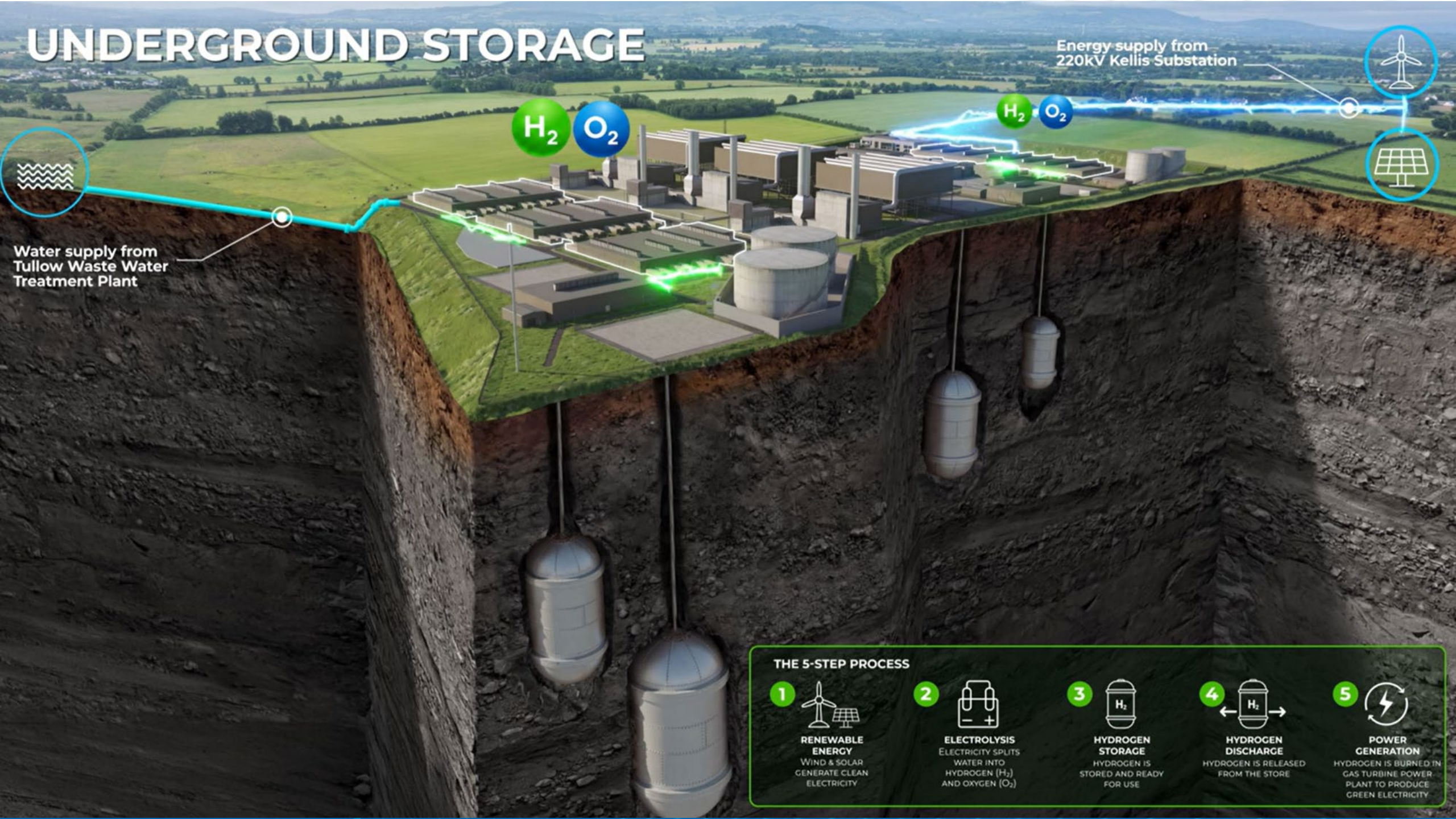


620MW
70hrs LDES on H_2

3,000t H_2 30-220bar
350hrs HVO

50 acres
Kellis 220kV 3km
Carlow

30x more energy than Turlough Hill
7x more power than Ardnacrusha
1TWh/yr (HHV) of hydrogen production
10% of Ireland's peak demand today

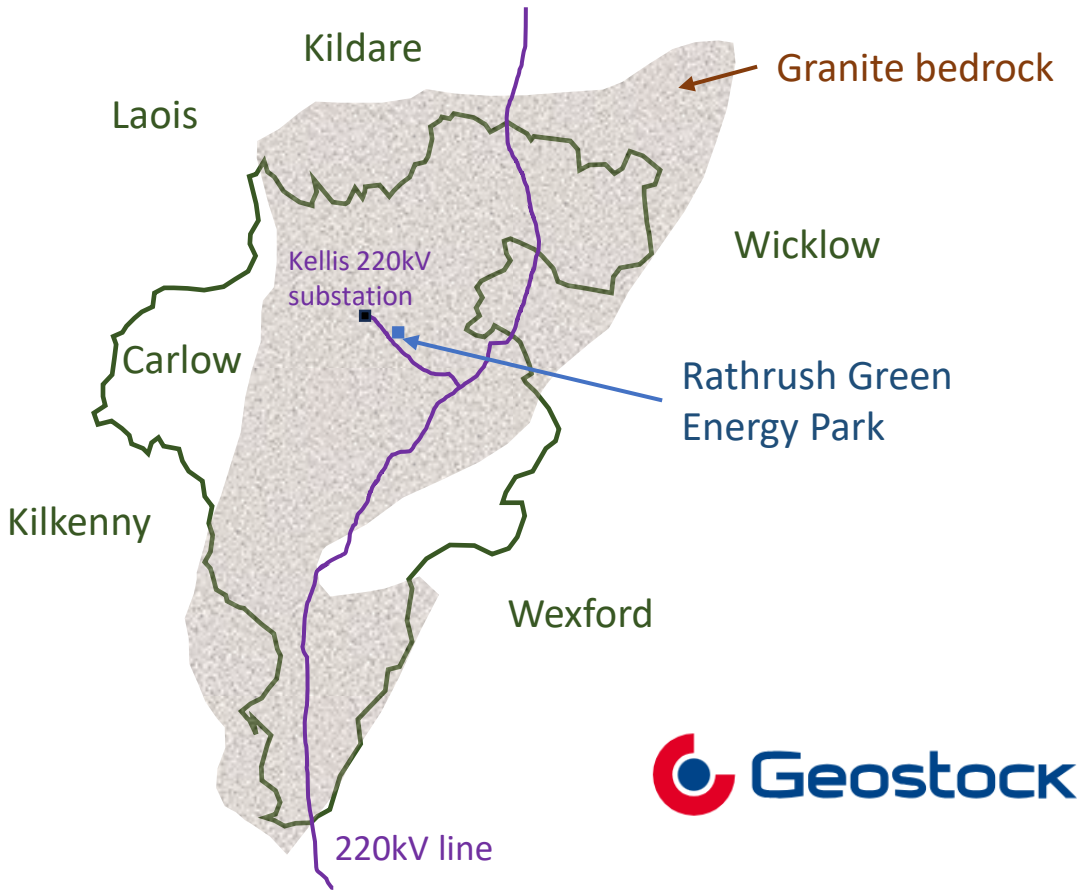

UNDERGROUND STORAGE
Energy supply from
220kV Kellis Substation
H_2
O_2
H_2
O_2
Water supply from
Tullow Waste Water
Treatment Plant
THE 5-STEP PROCESS
1
RENEWABLE ENERGY
WIND & SOLAR GENERATE CLEAN ELECTRICITY
2
ELECTROLYSIS
ELECTRICITY SPLITS WATER INTO HYDROGEN (H_2) AND OXYGEN (O_2)
3
HYDROGEN STORAGE
HYDROGEN IS STORED AND READY FOR USE
4
HYDROGEN DISCHARGE
HYDROGEN IS RELEASED FROM THE STORE
5
POWER GENERATION
HYDROGEN IS BURNED IN GAS TURBINE POWER PLANT TO PRODUCE GREEN ELECTRICITY

Lined Rock Caverns



- A cylindrical cavern c.**40m** diameter and **80m** high with domed self-supporting roof is excavated ~100-200m underground, lined with shotcrete and a stainless-steel gas-proof liner
- **Standard mining** techniques are used to excavate the cavern. Ideal rock is strong and unfractured, e.g. igneous rocks such as granite.
- The strength and safety comes from the millions of tonnes of rock sitting above the cavern.
- **Vinci Group** Construction (400,000 employees), part of Dublin Metro consortium, has reviewed the design and has confirmed it can be constructed.
- Skallen in Sweden has been operating for **22 years successfully** at similar scale and pressure, on methane.
- Hybrit in Sweden has conducted **50 year accelerated ageing** testing on ductile stainless-steel grades to confirm fatigue resistance to 250bar hydrogen (opposite), prior to full scale facility for green steel. EU funded.
- **5-step scale up plan** to increase build confidence and experience

Site Selection



Our site is in Rathoe townland, in the Rathrush electoral division, near Rathoe and Tullow, Carlow

- **Granite** is ideal for tunnelling and caverns, low levels of ground water, strong, fault free.
- Proximity to 220kV **substation** at Kellis
- Appropriate **setbacks** from housing and settlements
- Achieve low-moderate visual impact
- Good road access
- Avoiding environmental or archaeological constraints

There are around 10 other regions also with suitable rock near 220kV substations.

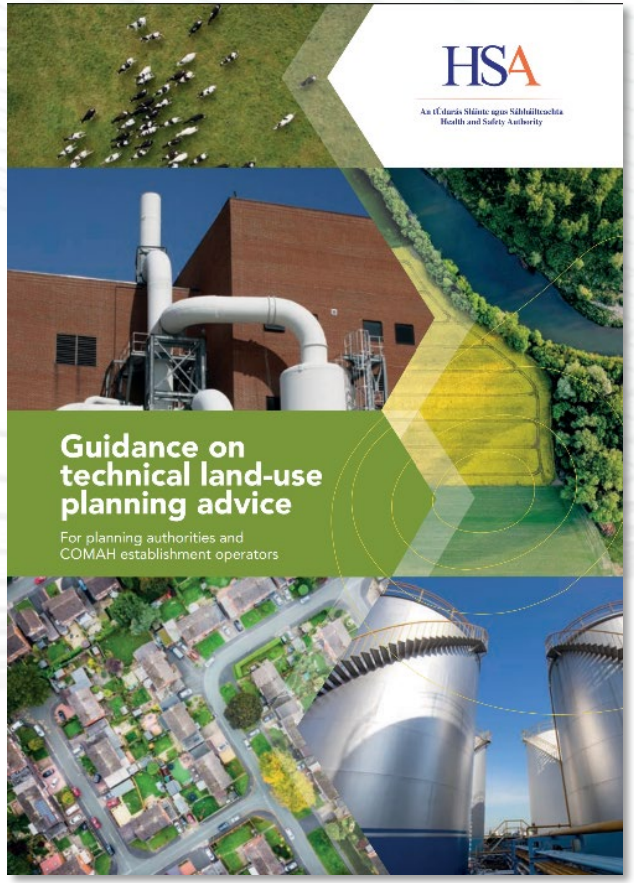
Safety And Oversight



- Safety is the foremost consideration in the siting, design, construction and operation of the Rathrush facility.
- Hydrogen will be stored in purpose-built lined rock caverns c.100m below ground in granite bedrock.
- The site will be subject to regulation by the Health and Safety Authority of Ireland (HSA), under **COMAH** regulations.
- COMAH is the regulatory framework used to oversee major energy and industrial facilities and is designed to protect people, communities, and the environment.
- Due to the scale of storage proposed, the establishment will be designated "**Upper tier**" under COMAH, requiring the highest level of safety management and risk assessment.
- Similar Upper Tier COMAH facilities operate safely throughout Ireland, with around 50 establishments currently in operation.

Land Use Planning Study

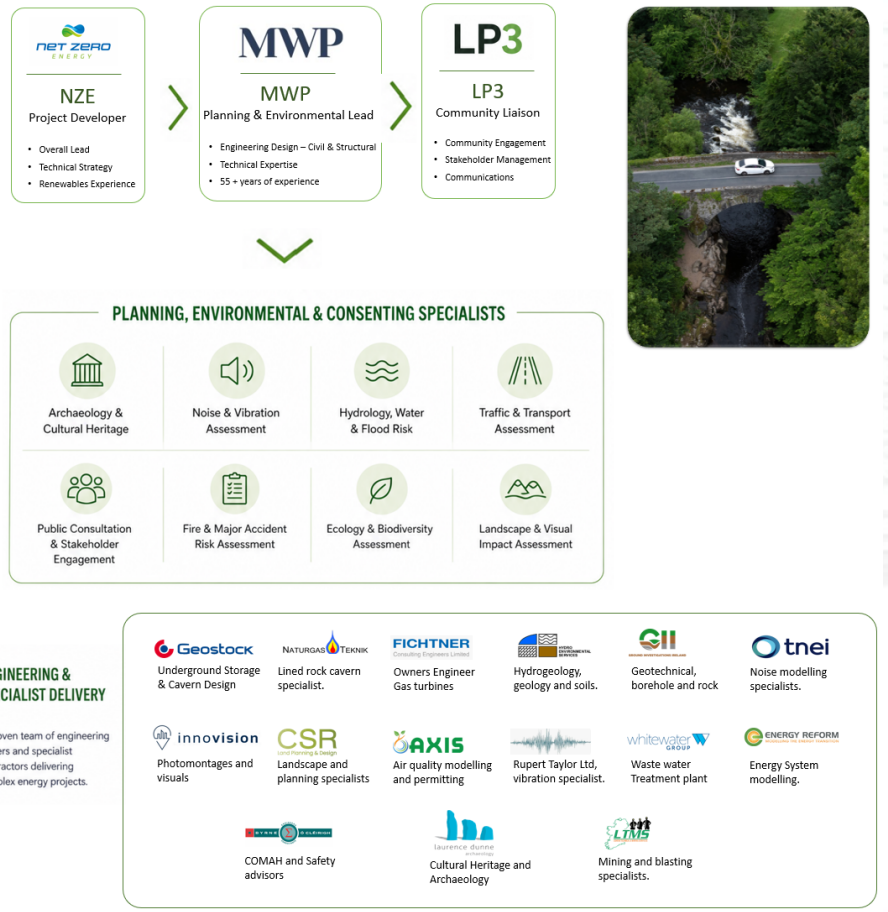
- The project will comply with Ireland's COMAH regulations
- A detailed Land-use Planning (LUP) and Risk Assessment has been completed in accordance with Health and Safety Authority (HSA) guidance and will be submitted with the planning application.
- The HSA is a Statutory Consultee in the planning process
- The assessment examined potential effects on neighbouring homes, businesses, and the surrounding community.
- The results demonstrate that the potential off-site effects are very low and fall well within the HSA's accepted public safety limits.
- NZE has had extensive engagement with the HSA over the past year and they have now completed their review of our Draft LUP Risk Assessment Report and have '***no further observations to make***'. They will make their final decision through the planning process.



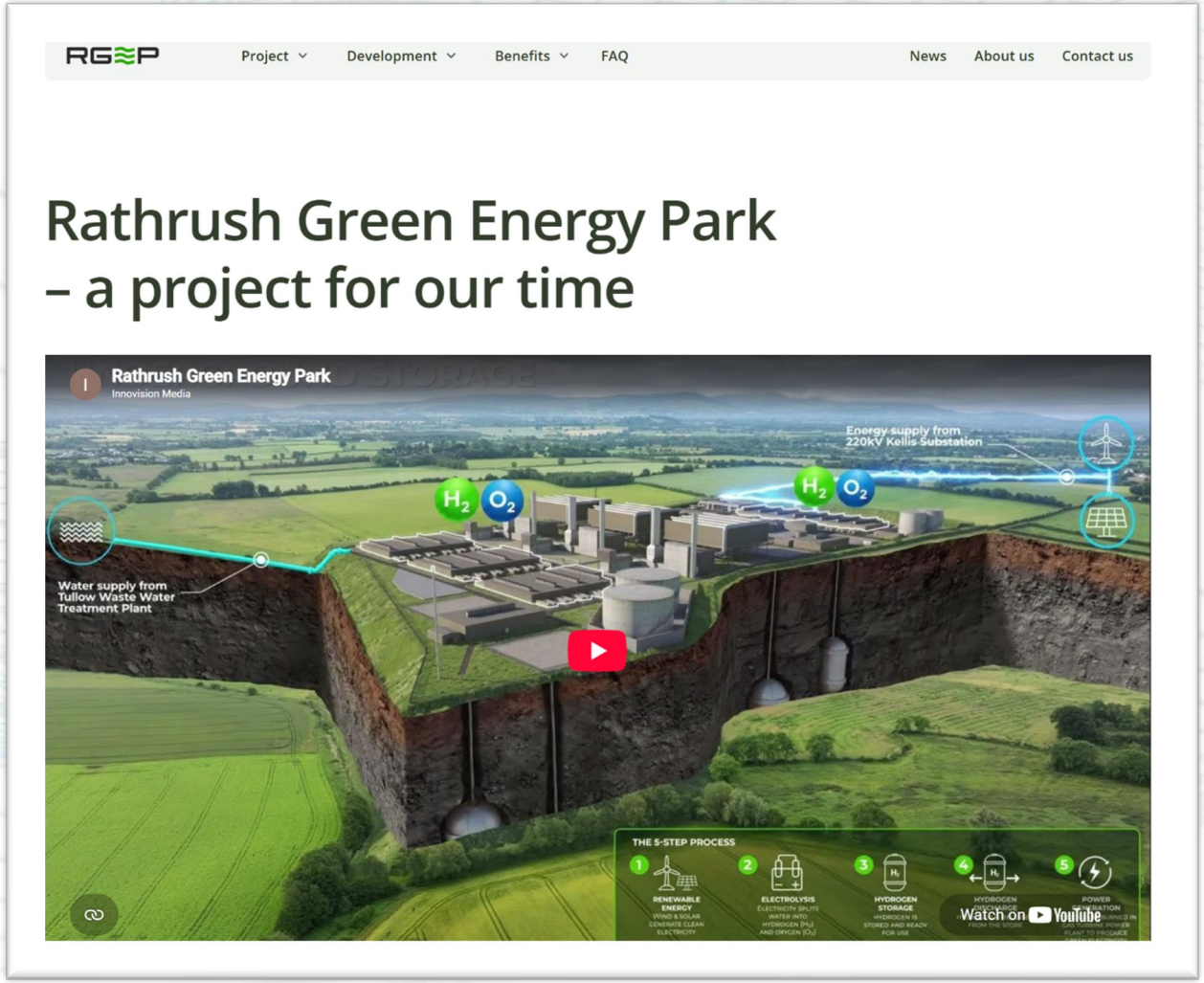
Planning Preparation

On track for submission in December 2026

Workstream	RAG	Position
Statutory & COMAH	Complete	All necessary statutory consultations and COMAH land use planning complete
Noise	Complete	Study complete. Plant achieving 35 dB at night in a low-noise environment
Air quality	Complete	Air dispersion modelling complete and compliant, stack 45m
Blasting & vibration	Complete	Strategy and vibration modelling complete and compliant (PPV)
Visual impact	Complete	“Low to moderate” in a non-sensitive designated area of the Carlow County Development Plan
Grid & utility routes	Complete	Capacity modelled as available at Kellis. Grid and water routes designed and mapped. Capacity confirmed by Uisce Eireann.
Water & hydrogeology	Complete	Testing and modelling complete. Low groundwater movement in granite, with no concerns raised
Construction facilities	Complete	Compound layouts and temporary explosives stores designed and agreed with relevant authorities
ACP Pre-Application	Complete	ACP has confirmed no further meetings to close.
Public consultation	Complete	Sufficient consultation complete
Additional commitments	Planned	Further public consultation and testing of nearby private wells



Discussions & Questions



www.rathrushgreenenergypark.ie