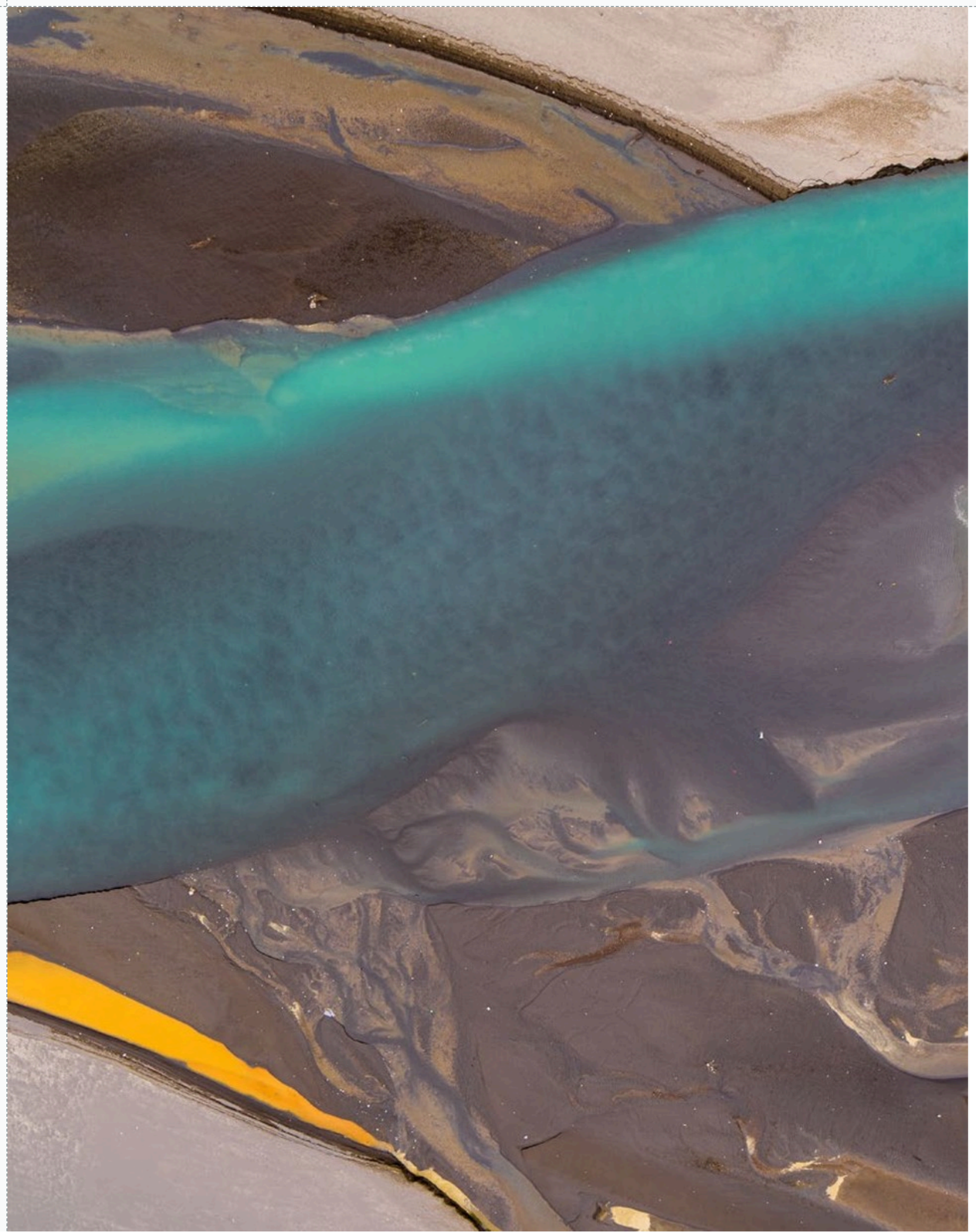
Natural Hydrogen Production Platform

Connected Modelling from
Exploration to Real-Time Operations

PETEX

SEAMLESS INTELLIGENCE. GLOBAL IMPACT.

Contents



ONE CONNECTED ENVIRONMENT 03

THE NATURAL HYDROGEN SYSTEM 04

GEOLOGICAL INTELLIGENCE 06

DYNAMIC MULTI-PHYSICS SIMULATION 07

HYDROGEN PHYSICS,
BUILT AND VALIDATED 08

NETWORK MODELLING 09

CONNECTING TO THE PROCESS PLANT 10

VISUAL INTEGRATION
AND WORKFLOW AUTOMATION 11

ENTERPRISE REAL-TIME ASSET MANAGEMENT 12

CAPABILITIES ACROSS THE
NATURAL HYDROGEN LIFECYCLE 13

One connected environment for natural hydrogen assets



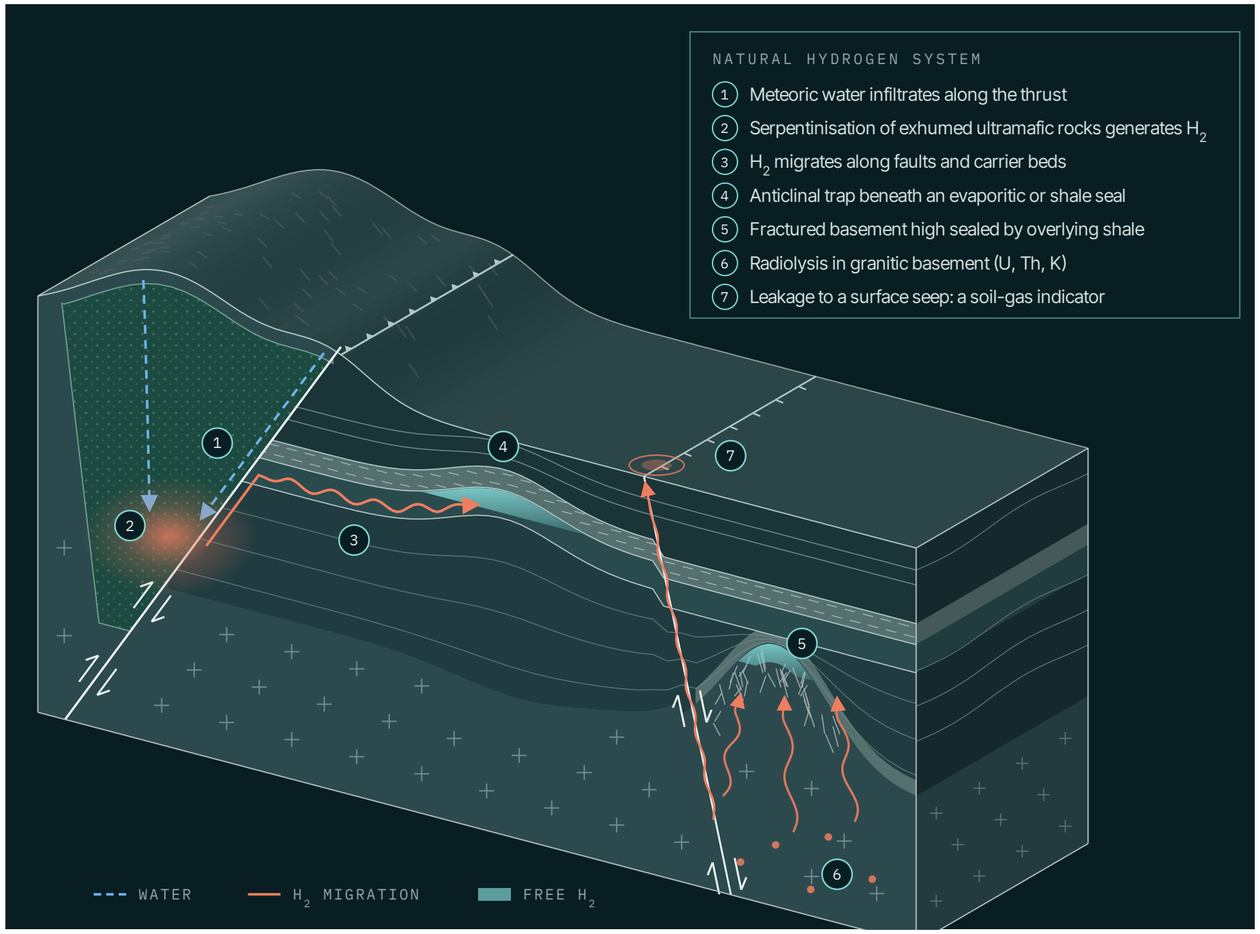
Natural hydrogen projects depend on coordinated decisions across exploration, source and trap assessment, reservoir behaviour, production wells, gas gathering, processing and purification.

These areas are frequently assessed in separate applications, making it difficult to understand how a decision in one part of the project affects the complete asset. PETEX connects these systems through physics-based models, visual engineering workflows and our Digital Operations Framework.

From the first exploration well to full-field operations, the same connected environment characterises the resource, forecasts long-term behaviour, designs wells and networks, automates multidisciplinary studies and supports operating decisions. It is a closed loop, not a hand-off chain: measured operating data returns to the models that produced the plan, and the plan is re-optimised against it.

The Natural Hydrogen System

Natural hydrogen accumulates where a source generates it, faults and fractures carry it, and a trap and seal hold it long enough to be produced. Each element is uncertain, and each uncertainty can be carried into the models as a scenario before drilling.



GENERATION

Water–rock reactions that oxidise ferrous iron in ultramafic and mafic rocks (serpentinisation), and radiolysis of water by uranium, thorium and potassium in granitic and Archaean basement.

MIGRATION

Faults, fractures and permeable pathways connect source and trap; the tectonic setting controls how close source rocks sit to reservoirs and seals.

ACCUMULATION

Fractured basement or sedimentary reservoirs beneath volcanic, evaporitic or shale seals, where hydrogen is held as free gas, dissolved in formation water, or both.

PRESERVATION

Microbial consumption (below about 122 °C), rock reactions and diffusion remove hydrogen over time; how much is preserved, as free gas or in solution, controls recoverable volumes.



SUBSURFACE

RESOURCE & RESERVOIR

Source, migration, trap and seal, reservoir and fracture properties, free gas versus dissolved hydrogen, pressure and recovery through time.

WELLS

PRODUCTION & TESTING

Completions, inflow and outflow for low-density hydrogen-rich gas, well testing, water lift and energy demand.

SURFACE

GATHERING & NETWORK

Pipelines, compression, separation, blending of gas streams and produced-water disposal constraints.

PLANT

FACILITY & INTERFACES

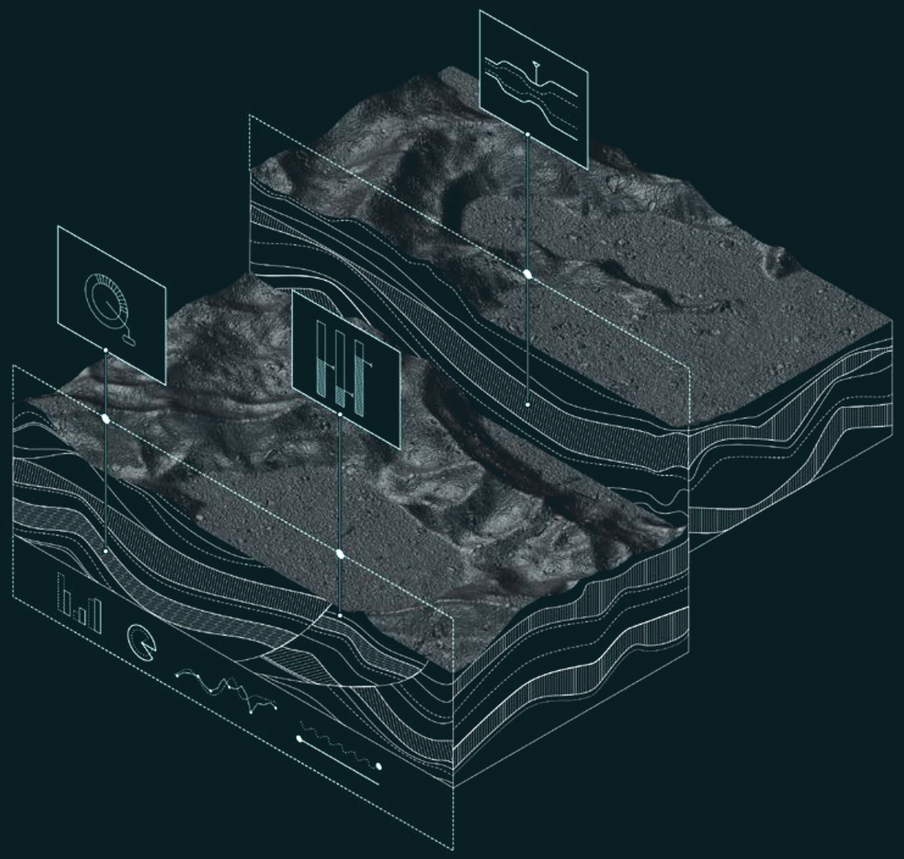
Links to the process models used for the facility: inlet conditions, capacity, specifications and bottlenecks.

Visual integration and workflow automation across all four.

Digital Operations Framework: governance and real-time operations.

Geological Intelligence and AI-Driven Exploration

Establish the three-dimensional geological and structural framework – source, pathways, reservoir and seal – used throughout the natural hydrogen workflow.



CAPABILITIES

- Geological, structural and stratigraphic modelling
- Mapping of hydrogen source rocks: ultramafic units (serpentinisation) and uranium-, thorium- and potassium-rich basement (radiolysis)
- Kinematic restoration of rift, inversion and other tectonic settings; stress, fault-response and geomechanical analysis
- Discrete Fracture Network modelling and fault-seal analysis; migration pathways, trap geometry, and compartmentalisation
- Dual-porosity fracture properties (spacing and sigma factor) exported directly to the reservoir simulator
- Geological uncertainty assessment and consistent inputs for dynamic simulation
- Iterative drilling-location selection and comparison of exploration and data-acquisition strategies

DRILLING RESULTS → UPDATE THE MODEL → QUANTIFY UNCERTAINTY → IDENTIFY NEXT TARGET

Each well sharpens the next target.

Dynamic Multi-Physics Simulation of Natural Hydrogen Systems

Model how hydrogen-rich gas, formation water and fractured host rock interact under production, combining dynamic flow with hydrogen-specific PVT, solubility, exsolution and fracture behaviour.

CAPABILITIES

- Free-gas and dissolved-hydrogen systems: gas cap with aquifer, or hydrogen held in solution
- PVT for hydrogen-rich mixtures (H_2, N_2, CH_4, He) with an equation of state (EoS) tuned to the gas composition
- Hydrogen solubility in formation water through PHREEQC coupling, calibrated to experimental data across pressure, temperature and salinity
- Exsolution of dissolved hydrogen as pressure falls, with free gas and dissolved concentration reported in 3D
- Hydrogen–water relative permeability and dual-porosity fracture–matrix flow
- Thermal effects on fluid properties, solubility and well performance
- Fracture-intensity, pressure-support, overpressure and salinity sensitivities on deliverability
- Forecasting of hydrogen mass, gas composition and water production, with mass-balance checks

FLOW

Pressure, communication, gas–water contacts

PVT

Hydrogen-rich mixtures, EoS selection

SOLUBILITY

Gas–water partitioning, salinity, exsolution

FRACTURES

Dual porosity, matrix transfer

WELL BUILDER

Production and appraisal well modelling

CAPABILITIES

- Production well models, completions, multi-laterals and multi-tubing configurations
- Inflow, outflow and hydraulic performance for low-density, low-viscosity gas; lift curves generated with the fluid model best suited to the composition
- Implicit mass and heat transfer in the wellbore; transient unloading
- Water lift for dissolved-hydrogen cases; rate forecasting, sensitivities and diagnostics

WHERE THE MODEL SITS

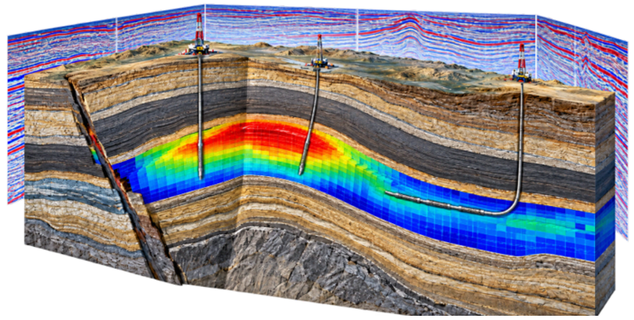
Reservoir conditions

Well performance

Surface requirements

Hydrogen Physics, Built and Validated

Hydrogen is very light, low in viscosity and sparingly soluble in water, so it flows and partitions differently from hydrocarbon gas in the reservoir and the well. PETEX has extended its simulation physics for hydrogen-rich systems and checks each physical effect against reference data before combining them at reservoir scale.



WHY IT MATTERS

- Whether hydrogen sits in a free-gas phase or in solution controls recoverable volumes
- Low density and viscosity change pressure losses in the reservoir and wellbore
- Pressure and salinity control how much hydrogen stays dissolved in formation water
- Gas released near the well can remain below critical saturation and stay immobile

PVT

Hydrogen-rich mixtures with nitrogen, methane and helium are characterised in PVTp, with the equation of state selected and tuned to the gas composition.

SOLUBILITY

The PHREEQC database is tuned to reproduce experimental hydrogen solubility across temperature, pressure and salinity, with hydrogen treated as chemically inert or reactive.

EXSOLUTION

Dissolved hydrogen comes out of solution as pressure falls below its saturation pressure, verified with mass-balance checks from initialisation through production.

AUTOMATION

Calibration and sensitivity runs across salinity, temperature and pressure are automated through Python and RESOLVE workflows.

Validated in isolation, then combined at reservoir scale.

Surface Gathering, Compression and Produced-Water Networks

Connect wells, pipelines, compressors, separators, facilities and produced-water systems within one hydraulic network model.

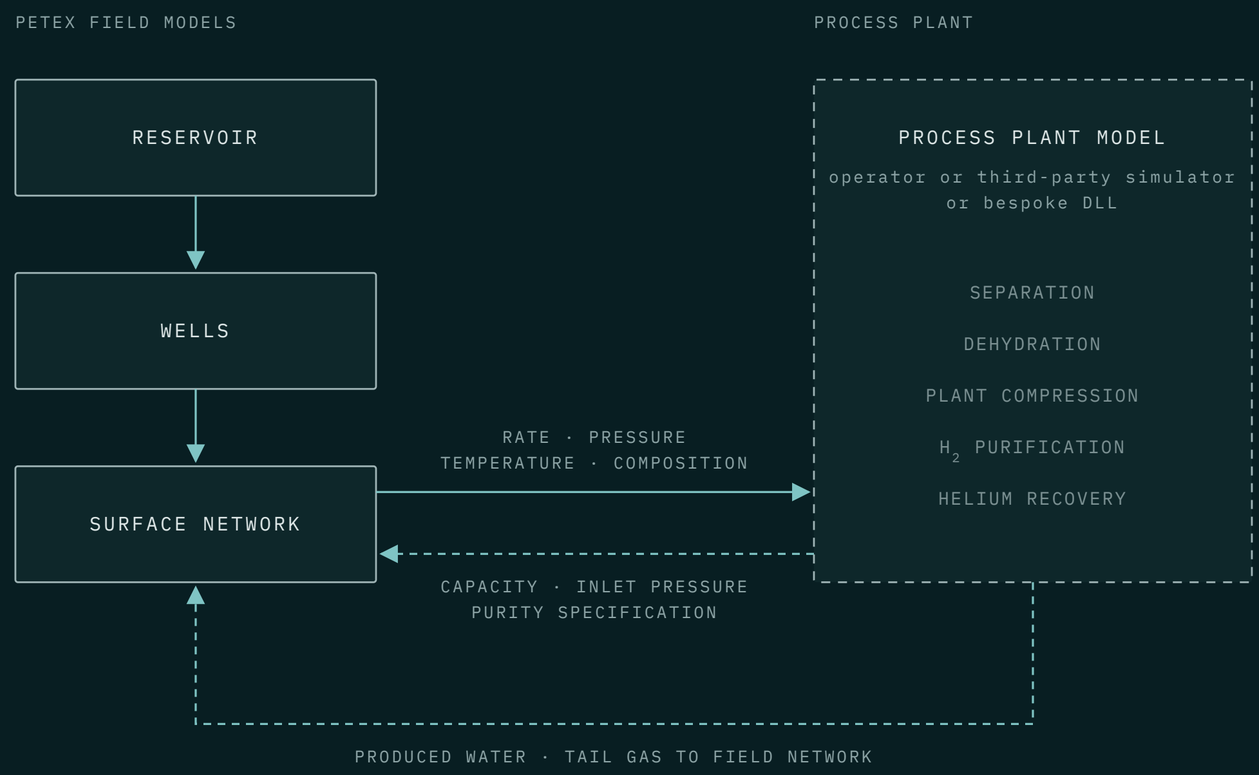
- Gathering and produced-water disposal or reinjection network simulation
- Pipeline pressure losses, velocities and routing for hydrogen-rich gas, with equation-of-state selection
- Compression, pumping and energy requirement analysis
- Blending of gas streams with different hydrogen, nitrogen, methane and helium contents
- Steady-state and transient network behaviour
- Surface, facility and export-specification constraint management
- Production optimisation; network capacity and alternative configuration assessment



Connecting to the Process Plant

Value is realised at the plant. The platform connects field forecasts to the process models already used for the facility, so plant constraints and field behaviour are evaluated together.

- Links to operator or third-party process simulators through open interfaces
- Operator plant or unit models connected through bespoke DLLs
- Plant inlet rate, pressure, temperature and gas composition passed from the field models
- Plant capacity, inlet pressure and purity specifications returned as network constraints
- Produced-water and tail-gas return streams passed back to the field network
- Field-to-plant scenarios run and compared in visual workflows



FLOW RATE PRESSURE TEMPERATURE COMPOSITION

Plant constraints flow back to the field models – field and plant solve together.

Visual Integration and Workflow Automation

Connect PETEX applications, third-party tools, data sources and engineering calculations within controlled visual workflows.

- Native PETEX integration and connection to third-party engineering tools
- Vendor-neutral architecture; visual, no-code configuration
- Automated exchange of model inputs and results
- Multi-model execution and calculation sequencing
- Scenario generation, iterative loops and optimisation orchestration
- Automated sensitivity runs across pressure, temperature and salinity
- Automated reporting; distributed and cluster-based execution
- Integration with hydrogen and associated-gas geochemistry, PVT and laboratory data, economic, environmental and operational systems





Enterprise Real-Time Asset Management

Our Digital Operations Framework turns the connected engineering models into a living representation of the asset, combining data, models, workflows, governance and visualisation across engineering, operations and management.

- Common view of geology, reservoir, wells, networks, facilities, operations and economics
- Connection to laboratory information, gas analysers, operational databases, SCADA and historians
- Data acquisition, validation, cleansing, contextualisation, event detection and smart alarming
- Model Catalogue: versioning, validity dates, access control, change tracking and auditability
- Visual workflows for surveillance, diagnostics, validation, forecasting and optimisation
- Measured performance compared against validated physics-based models
- Short- and long-term forecasting of hydrogen and helium production, gas composition, water and plant feed
- Full-asset optimisation across recovery, feed-gas quality, compression energy, water, throughput, cost and value
- Configurable dashboards, maps, trends, reports and alarms
- Scalable from one well or facility to multi-asset portfolios

Capabilities Across the Natural Hydrogen Lifecycle

EXPLORATION AND CHARACTERISATION

- AI-supported drilling campaign optimisation
- Source, migration, trap and seal assessment
- Free-gas versus dissolved-hydrogen volumetrics
- Progressive reduction of subsurface uncertainty

DEVELOPMENT AND DESIGN

- Well location, well type and well-test design
- Dynamic recovery scenarios
- Integrated well, network and plant-constraint analysis
- Data-acquisition planning to target key uncertainties

OPERATIONS

- Real-time surveillance and contextualised operational data
- Model-based diagnostics, smart alarms and forecasting
- Production, compression and network optimisation

ASSET MANAGEMENT

- Governed data, models and workflows
- Engineering knowledge and repeatable decision processes
- Visibility from individual equipment to complete portfolios

What happened?

Historical and operational data.

What is happening?

Current well, field, network and facility performance.

Why is it happening?

Physics-based diagnostics and comparison of measured and modelled behaviour.

What is likely to happen next?

Dynamic forecasting and scenario simulation.

What should be done?

Workflow-driven evaluation, optimisation and operational recommendations.

What is the impact?

Assessment against production, recovery, gas quality, energy, facility, operational and economic objectives.



Connected physics. Connected workflows. Connected operations. Connected value.

PETEX provides an integrated digital environment connecting exploration, geological characterisation, dynamic hydrogen simulation, production wells, surface infrastructure and real-time asset management, with open links to process plants.

By combining physics-based models, AI-supported exploration, third-party integration, visual workflow automation and our Digital Operations Framework, the platform supports consistent decisions throughout the complete natural hydrogen asset lifecycle.

PETEX

ENGINEERING SOFTWARE DEVELOPMENT

MINING AND HYDROGEN DEPARTMENT

operations@pe-mining.com

HEAD OFFICE

PETEX
3000 Cathedral Hill,
Cathedral Square, Guildford,
GU2 7YB, UK

+44 (0) 131 474 7030
edinburgh@petex.com

REGIONAL OFFICE

Petroleum Experts Inc.
757 N. Eldridge Pkwy.,
Suite 510,
Houston, Texas,
77079, USA

+1 281 531 1121
houston@petex.com

---

www.petex.com