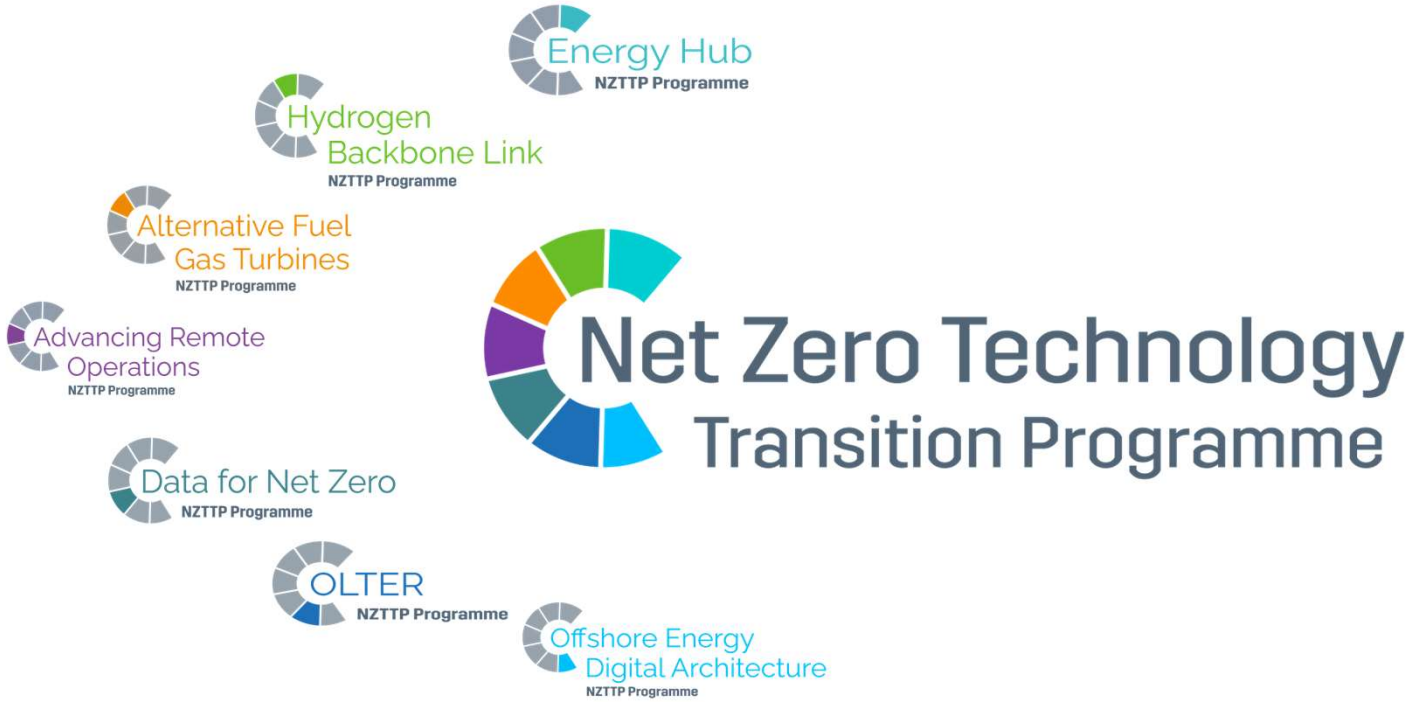
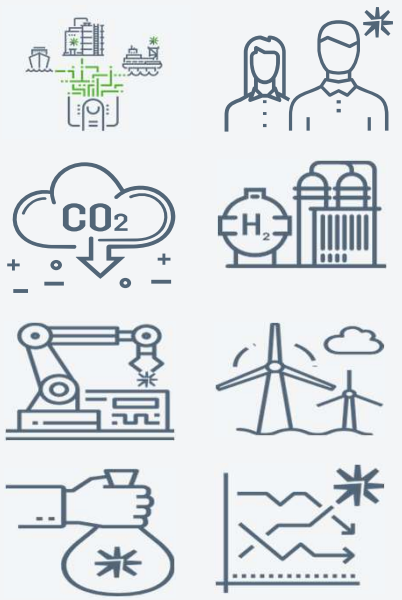


NZTTP-PRE-068-01

Net Zero Technology Transition Programme

Offshore Energy Digital Architecture	Offshore Energy Digital Architecture	Implementing a sector-wide data and infrastructure strategy to enable digitisation.
Data for Net Zero	Data 4 Net Zero	Developing analytics to unlock energy transition action and deliver the world's first smart energy basin.
Advancing Remote Operations	Advancing Remote Operations	Remote operations to create safer, more efficient and lower carbon operations.
OLTER	Offshore low touch energy robotics & autonomous systems	Enabling next generation robotics and autonomous systems for the offshore energy sector.
Energy Hub	Energy Hub	Identifying key opportunities and technologies to deliver the nations future low carbon energy requirements
Hydrogen Backbone Link	Hydrogen Backbone Link	Scotland in a leading role for the development of pan-European hydrogen infrastructure
Alternative Fuel Gas Turbines	Alternative Fuel Gas Turbine	Accelerating development of gas turbines capable of running on clean fuels.



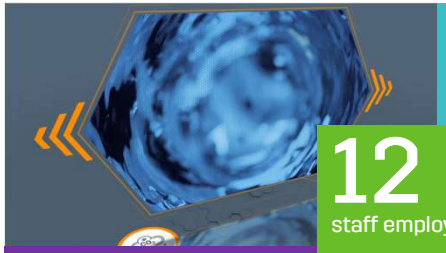
7 integrated projects

£16.5m

3 years

Industry matched

NZTTP strong delivery year 1



£5.8m invested by Scottish Government

66 industry support partners

12 staff employed

100+ companies & organisations engaged

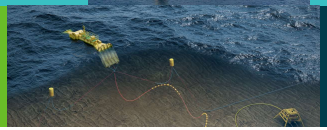
5 secondees

£7.2m+ leveraged from industry partners

12 tenders via PCS

£2-5bn GVA potential

7 projects



3+ field trials planned

The Scottish Government
Riaghaltas na h-Alba

60+
Companies Organisation

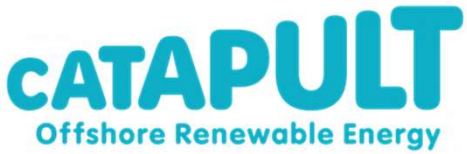
6+
Supporting more than 1

- Industry lead projects
- Cash & benefit in kind realised
- Engagement journey continues


Offshore Energy
Digital Architecture
NZTTP Programme

Industrial Data Hub

ARUP



OEDA

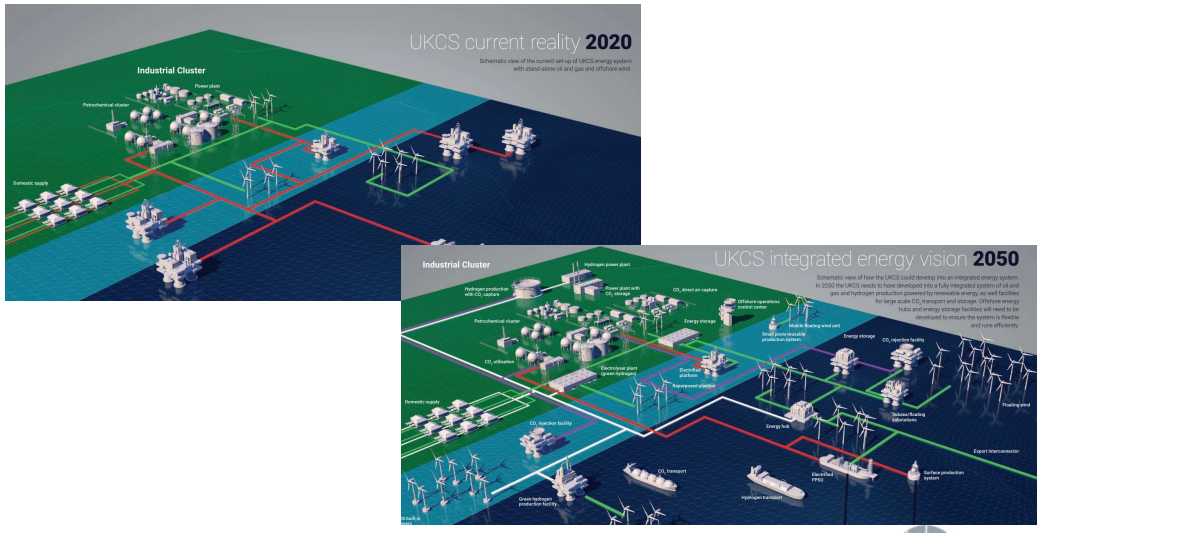
OEDA Aims

A sector wide data and digital infrastructure to demonstrate that we can secure, capture and transport industry data.

Using existing tools, techniques, and approaches required to successfully integrate disparate technologies and collaborate around industry data sets.

OEDA Key Components

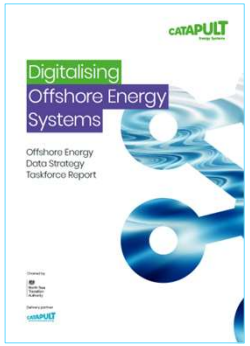
Robust, adaptive, secure communications architecture - The development of the architecture design that supports the secure capture, and transport of data.
Energy system data catalogue –Develop the design architecture that provides the visibility of data repositories.
Offshore energy data hub –Develop the architecture and potential operational systems design that will support the ability for any actor to gain appropriately controlled access.



Offshore Energy Digital Architecture
NZTTP Programme

OEDA – Summary

WHAT: Collaborate and make visible datasets and create a common data architecture that will enable a greater energy transition.
HOW: Palantir's Foundry system is chosen data platform for data catalogue and data hub.
WHO: InDhu, experienced solution providers using Foundry in aviation will be the lead delivery partner.
WHY: Drive collaboration and data sharing across the offshore energy sector.



CREATE A MODERN, DIGITALISED AND INTEGRATED OFFSHORE ENERGY SYSTEM

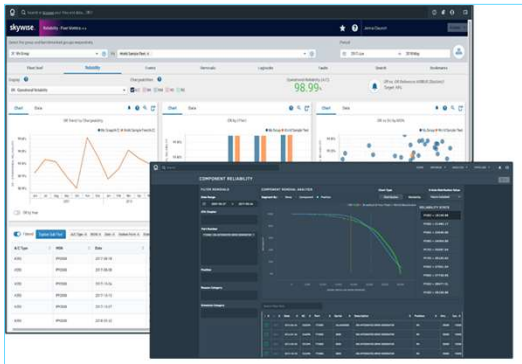
2: DELIVERING A COMMON DATA TOOLKIT

Actions
- Deliver an Offshore Energy Data Catalogue
- Deliver the Data Sharing Fabric digital infrastructure
- Facilitate data interoperability initiatives

Offshore Energy
Digital Architecture
NZTTP Programme

OEDA – Analogous Use Cases

Offshore Energy Digital Architecture
NZTTP Programme



Challenge

Most airlines do not have up-to-date visibility into their reliability metrics. By the time airlines are able to amalgamate, analyze and report fleet-wide data at scale, weeks have past and the data is out of date.

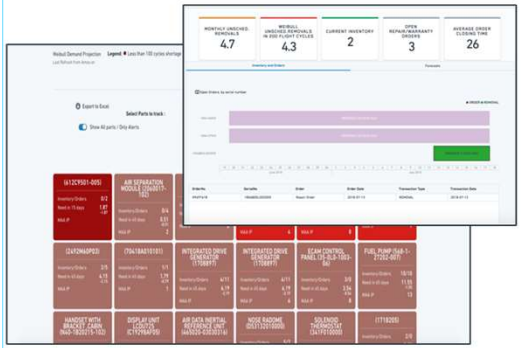
Skywise Solution

Skywise integrates all relevant fleet-wide data to give airlines a current view of fleet performance for the first time. Skywise also compliments an airline's internal data with world-wide anonymized fleet data so that airlines can proactively assess performance against industry benchmarks. By fully automating reliability reporting, Skywise saves airlines hours per week.

Skywise Impact

A regional reports a reduction of **20 AOGs** and **3,300 hours of manual reporting** and **cost savings of USD500k** from improved campaigns.

REQUIRED DATA	PART REPLACEMENTS	FLIGHT PLANS	DELAYS	MAINTENANCE LOGS
USERS	RELIABILITY	MANAGEMENT		



Challenge

Materials are distributed across multiple warehouses and multiple teams. Inventory status is tracked manually, and is often opaque. Collating and analyzing historical trends is nearly impossible.

Skywise Solution

Skywise syncs inventory data from across warehouses to past maintenance events and upcoming part requests to identify historical trends and optimize purchasing.

Skywise Impact

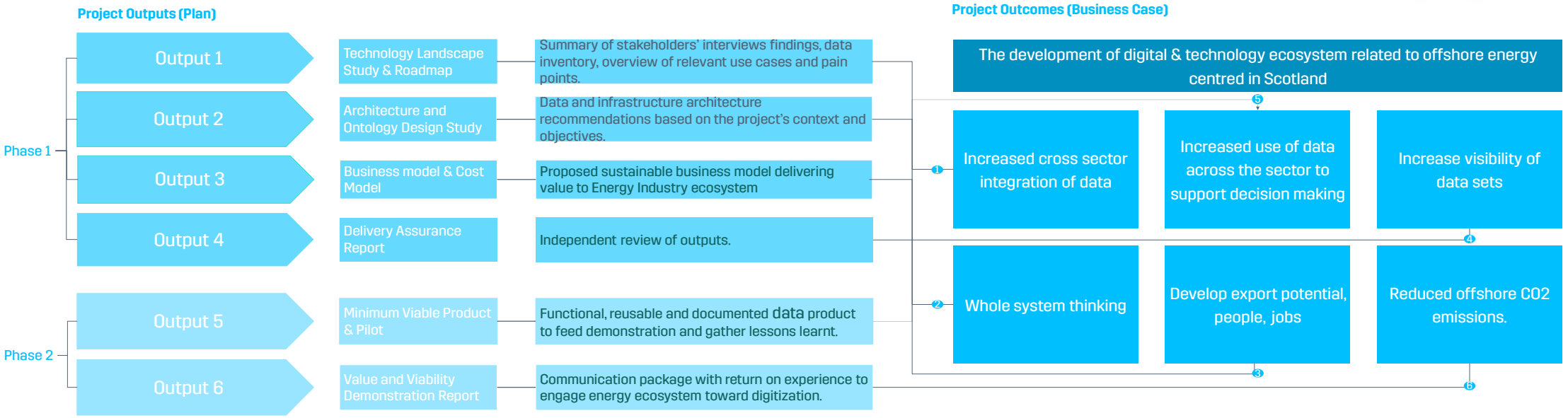
An APAC carrier used Skywise to identify significant excess stock. A 10% reduction in these parts equates to **$84 million in capital.**

A low-cost carrier **reduced inventory tracking time from 10 hours per week to less than 1 hour.** While previously managers could only track 89 parts, they can now track 3566.

REQUIRED DATA	AIRCRAFT	PART REQUESTS	COMPONENT REMOVALS / INSTALLS	INVENTORY DATA
USERS	OPS	PLANNING	MATERIALS MANAGEMENT	

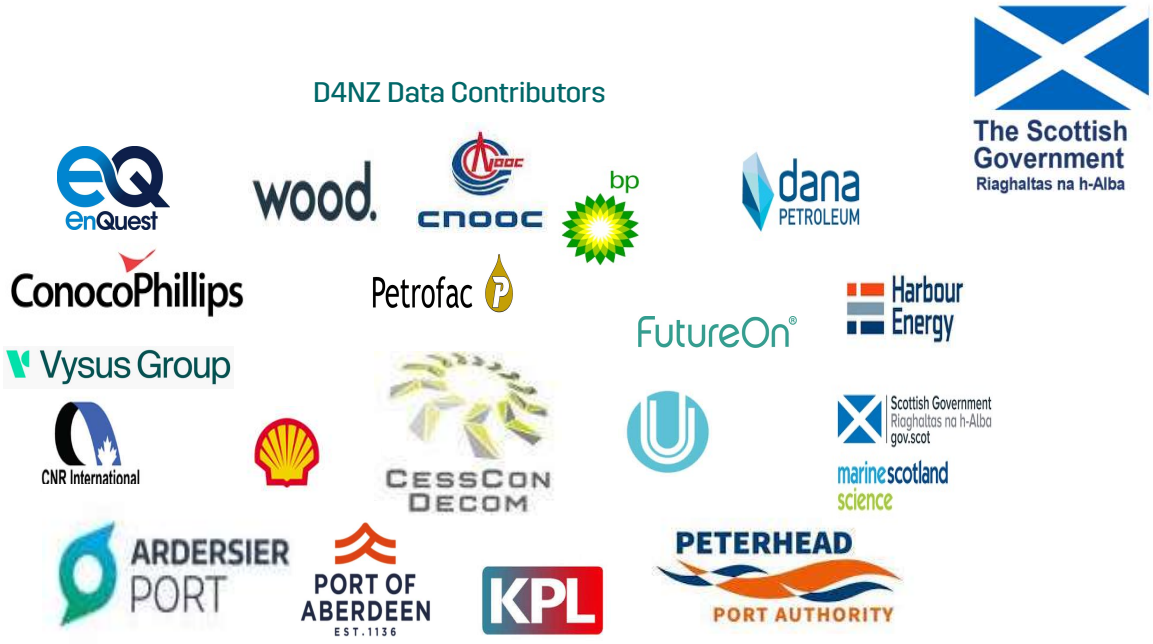
OEDA – Outputs and Outcomes

Offshore Energy Digital Architecture
NZTTP Programme




Data for Net Zero
NZTTP Programme

D4NZ Data Contributors



D4NZ Stakeholder Advisory Group / Steering Committee

Key Objectives

Demonstrator of the world's first Smart Energy Basin Service that will:

- Connect the energy landscape at basin level and across sectors to support technical, and economic efficiencies
- Trial new technology and solutions in a virtual environment
- Utilise simulation, AI technology and algorithms to allow multi-disciplinary trade-off analysis for decision making

Three year collaborative project

Key Outputs

- Demonstrator of the world's first integrated Smart Energy Basin to accelerate net zero innovation at scale
- Full business case for a dedicated industry service for offshore simulation
- Anchor the supply chain by providing visibility of scopes, and promoting new ways of collaboration
- Promote better stewardship in the blue economy by managing inter-dependencies and common goal
- Build Academic expertise, Knowledge Portal and skills transfer

Virtual

Developing the **World's first smart energy basin** demonstrator starting with the East of Shetland Region

In collaboration with

The National Decommissioning Centre

National Subsea Centre

D4NZ Smart Energy Basin

The National Decommissioning Centre
Innovation through Partnership

Prof Richard Neilson – Centre Director Project lead

What?

A digital copy of UKCS, starting with the East of Shetland Region

Key Lessons

- Importance of cross industry input
- Data aggregation – legal principles
- Ensure 'early wins' add value

What's next?

- Identify and capture specific data sets
- Incorporate more renewables case studies
- Demonstrate approach with exemplar area
- Launch Smart Energy Basin Demonstrator project

1. Decarbonising Decommissioning

- Examine decommissioning within emissions context
- Examine emission reduction measures and opportunities
- Model and optimise technologies/techniques
- Support supply chain in decision making for investment

2. Decision Making in Late Life & Decommissioning

- Develop and integrate decision making tools
- Understand regulatory and process frameworks
- Prioritise decision making opportunities/targets
- Develop and run case studies and scenarios
- Incorporate renewables system/case studies

3. Infrastructure Re-Use & Re-Purposing & Energy Transition

- Establish a decommissioning timeline
- Understand regulatory context and challenges
- Model and visualise infrastructure interdependencies
- Examine optimal reuse and repurposing of infrastructure
- Map opportunities with potential for net zero

Key Output

- Stakeholder advisory steerco inaugural meeting held
- Mapping East of Shetland cluster complete.
- Data in the NSTA's NDR data base
- South Basin of Port of Aberdeen already modelled
- Novel offshore floating wind system and detailed wave tank tests for scenario planning underway
- Collating data on emissions from decommissioning Campaigns
- 2.5/3 FTE personnel recruited

D4NZ → AI for smart technologies

National Subsea Centre
Ocean Innovation through Partnership

Prof John McCall
Centre Director / Project lead

What?

Accelerate the Energy Transition through AI / smart technology applied to Subsea and related Marine Sectors

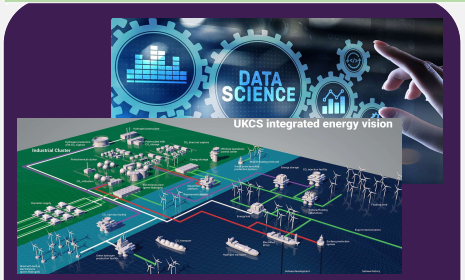
Key Lessons

- Importance of cross industry input
- Data aggregation – legal principles

What's next?

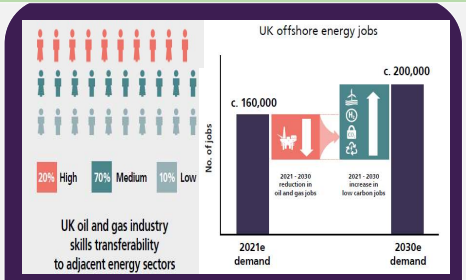
- **Acquire more industry data**
- **Recruit more researchers**
- **Trial Pilot predictive engines**
- **Draw alignment with ARO project**
- **'Integrate' existing decision making process marine simulation capability**
- **Launch Smart Energy Basin demonstrator project**

4. Energy Hub Body of Knowledge



- Survey suitable platform for energy grid modelling
- Design abstract network modelling layer
- Model basic KPIs (demand balancing, Capex. Opex)
- Integrate with multi-objective optimisation algorithms

5. UKCS Offshore Workforce Planning



Data driven workforce model, algorithms and tools than can efficiently match a large multi-skilled North Sea offshore workforce through:

- Automated tactical planning of operational tasks
- strategic training and workforce upskilling/re-skilling - Multi-level modelling and optimisation
- Accurate demand forecasting

6. Floating Offshore Wind/ Fisheries Predictive Planner

Smart planning system to optimise fishing / offshore energy activities/spatial patterns with net zero potential

Key Output

- Stakeholder advisory steerco confirmed and inaugural meeting held
- The data contractual discussions with 5 key industry partners
- Preliminary engines under development.
- Models of a novel offshore floating wind system scenario planning underway
- Collating data spatial fisheries patterns
- Recruiting for x2/x3 FTE personnel

Advancing Remote Operations

NZTTP Programme


Harbour
Energy


THE
DATA LAB
value from data


ITHACA
ENERGY


cnooc


BUREAU VERITAS
1828
BUREAU
VERITAS
Shaping a World of Trust


RGU
ROBERT GORDON
UNIVERSITY ABERDEEN


Petrofac


oeUK


TotalEnergies


Crondallenergy


Brainnwave


enrjon
NRG


SIEMENS
energy


The Scottish
Government
Riaghaltas na h-Alba


InDHu
Industrial Data Hub

Advancing Remote Operations

LEAD ROLE - NET ZERO TECHNOLOGY CENTRE

LEAD ROLE - INDUSTRY

EQUIP

- Tools
- Knowledge and Approaches
- Playbook and Landscape Study

PROVE

- Technology Development*
- Pilot(s) and Field Trial(s)

INSPIRE

- White paper
- Remote Operations Centre of the Future
- Events/conferences
- Website/Media/Video

ADOPT

- Adopt new technology and support commercialisation
- Embrace a new operating mindset
- implement into operations

SUPPORTING ROLE - INDUSTRY

Phase 1 – what have we done?

Advancing Remote Operations
NZTTP Programme

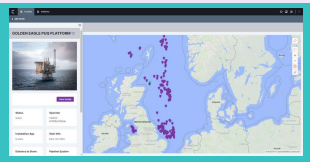
Key Objectives

- The widespread remote operation of UKCS assets
- Development of a centre of excellence and associated ecosystem
- The development of next generation skills and expertise in remote operations

Phase 1 – Key Work Packages

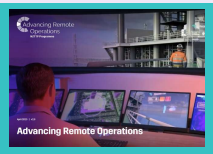
ARO Web Portal

- External face of project
- Central repository of deliverables



Asset Evaluation Tool

- Remote Operations decision support tool
- Identification and quantification of remote operations opportunities
- Configurable scenarios for individual asset(s)
- Aggregates asset data from NSTA data repository



Remote Operations Playbook

- Essential Remote Operations guidance
- Distilled knowledge and insights from a wide range of experts
- Includes RGU Workforce Dynamics study

Phase 1 >>> Phase 2

Landscape Study

- Cross-industry global overview of remote operations and centres
- Technology market overview for remote operations
- Highlighting the different options for the function of a ROCF

- Proving capability of remote operations technology
- Onshore and offshore pilot(s) and field trial(s) across different energy assets

Pilot(s) and Field Trial(s)

Key Outcomes

- Increased uptake of Remote Operations in the UKCS with a reduction in associated emissions
- Protecting and creating high value jobs in Scotland
- The establishment of the ROCE at the centre of a thriving ecosystem
- Improved worker safety, efficiency and CO2e reduction

Remote operations to create safer, more efficient and lower carbon operations.

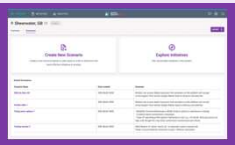
Phase 2 – what will we do?

Advancing Remote Operations
NZTTP Programme

Key Objectives

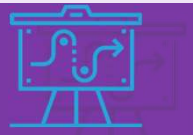
- The widespread remote operation of UKCS assets
- Development of a centre of excellence and associated ecosystem
- The development of next generation skills and expertise in remote operations

Phase 2 – Key Work Packages



Energy Asset - Evaluation Tool*

- Remote Operations decision support tool for energy assets enhanced by ChatGPT*
- Digitalises Remote Operations maturity model
- Technology, supply chain and workforce insights



Remote Operations Technology Playbook*

- Technical guidance for energy assets
- Pre-requisites, blueprints / architecture / digital foundations
- Remote Operations Technology Maturity Model

White paper*

- Remote Operations for the Energy Transition
- Captures project findings

Pilot and Field Trial

- Proving capability of remote operations technology
- Onshore and offshore pilot(s) and field trial(s) across different energy assets

Key Outcomes

- Increased uptake of Remote Operations in the UKCS with a reduction in associated emissions
- Protecting and creating high value jobs in Scotland
- The establishment of the ROCE at the centre of a thriving ecosystem
- Improved worker safety, efficiency and CO2e reduction

Remote operations to create safer, more efficient and lower carbon operations.

What's next?

- Landscape Study
- Phase 3 Remote Operations Centre of the Future

INTRODUCTION

Provide an overview of the NS UKCS, the benefits of deploying remote operations and its role in the future of the NS, and highlighting study objectives/aims

REMOTE OPERATIONS & CENTRES

Explore difference between remote operations, and remote operation centres and its varying types, and its core capabilities/functions

CROSS GEO O&G MARKET OVERVIEW

Collecting best practices, policies and key learnings across O&G markets, identifying characteristics of success

CROSS INDUSTRY GLOBAL OVERVIEW

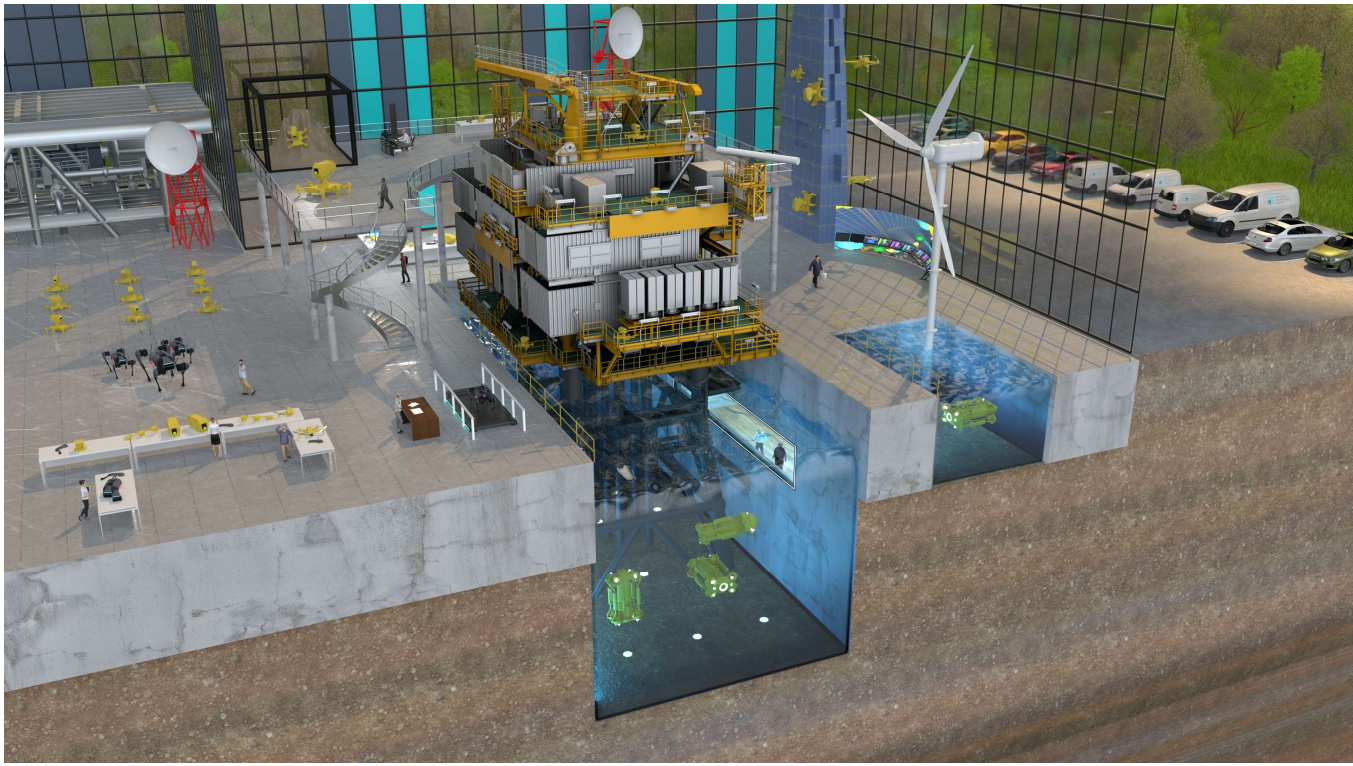
Collecting remote operations technologies, best practices, success factors and challenges across adjacent industries

NORTH SEA TECHNOLOGY OVERVIEW

Learnings and technologies from regions and industries are applied to the UKCS

REMOTE OPERATIONS CENTRE OF THE FUTURE

What can NZTC help with adoption and scale of remote operations of the future in the North Sea?




OLTER
NZTTP Programme


CATAPULT
Offshore Renewable Energy


THE NATIONAL
ROBOTARIUM
PEOPLE CENTRED :: INTELLIGENCE DRIVEN


technology
leadership board


D-RISQ
SOFTWARE SYSTEMS


Microsoft


accenture


Chevron


TotalEnergies


DRONEMAJORGROUP


Worley
energy | chemicals | resources


Lloyd's
Register


Ørsted


Innovate UK


HSE


SPRINT
ROBOTICS


Harbour
Energy


SCOTTISHPOWER
RENEWABLES


SSE


bp


mass
robotics


FLYLOGIX


UK Atomic
Energy
Authority

OLTER
NZTTP Programme

Key Workstreams

- RAS Service
- Competency Hub
- Data Hub

Phase 1 ▸▸ 12 months


Landscape Study


"Art of the Possible" Demonstrations


Knowledge Portal


Shared Analytics White Paper


BVLOS White Paper


Data Architecture

Phase 2 ▸▸ 24 months


Business Case, Roadmap & Value Proposition


Innovation & Workshop Space


Digital Marketplace


Hi-Fidelity Digital Twin


"Art of the Possible" Demonstrations


Best Practice

www.olter.co.uk

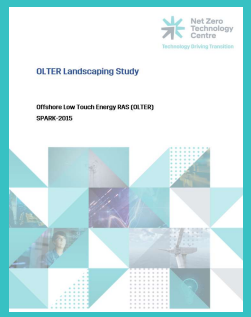
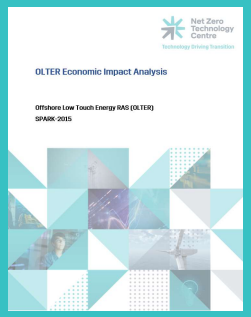
www.linkedin.com/company/olter-robotics-and-autonomous-systems/

Key Outcomes

- Dedicated Centre for Industrial Offshore Energy RAS with 2 Technical Hubs (Data and Competency Hubs)
- Digital Marketplace (relating to payload sensor algorithms)
- Hi-Fidelity Digital Twin Environment to simulate and test new RAS vehicles
- Knowledge Portal

OLTER provides the benchmark for development and use of reliable, on-demand, standardised autonomous systems.

OLTER
NZTTP Programme

Key Workstreams	Landscaping Study & Economic Impact Analysis	Key Findings
RAS Service	 	Barriers to RAS development, deployment and commercialisation • Fragmented approach • Lack of safety and assurance during development prevents deployment • Data sharing barriers • Lack of clear definition into what 'good' looks like to satisfy regulators • Lack of common technology testing methodologies • Lack of collaboration between ecosystem entities, which limits the scalability of RAS • Funding focusses on innovation, rather than facilitating progression from development to wide-scale applicability
Competency Hub		
Data Hub	Deloitte & OLTER Consortium	Gap in the market identified

Delivering an investible Business Case, Roadmap & Value Proposition

OLTER provides the benchmark for development and use of reliable, on-demand, standardised autonomous systems.

OLTER NZTTP Programme

Skyports

TBC

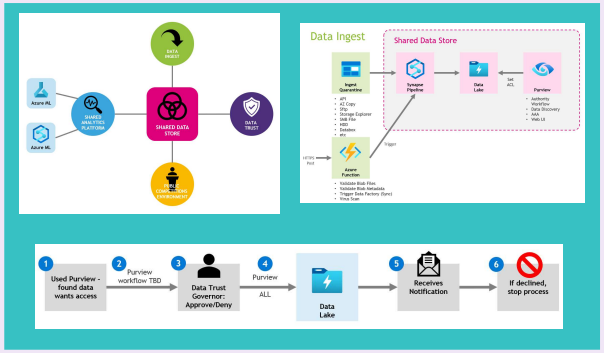
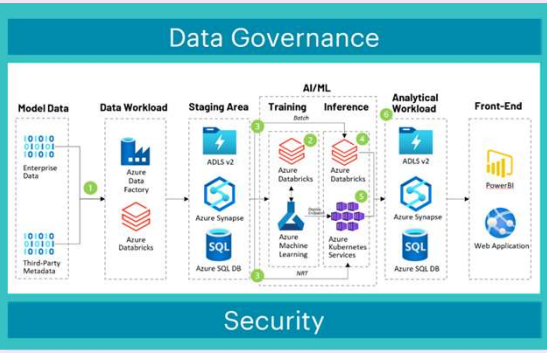
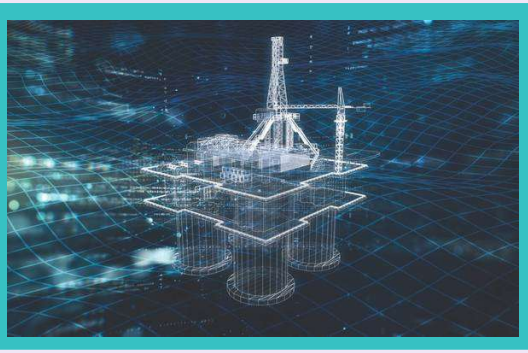
TBC

Key Workstreams	AIR	LAND	SEA
RAS Service			
Competency Hub			
Data Hub	BVLOS Payload Delivery	Ground Robots	Autonomous Surface Vessels

Onshore & Offshore Demonstrations, Technical Papers & Best Practice Development

OLTER provides the benchmark for development and use of reliable, on-demand, standardised autonomous systems.

OLTER
NZTTP Programme

Key Workstreams	Data Architecture	Shared Analytics Platform	Hi-Fidelity Digital Twin
RAS Service			
Competency Hub			
Data Hub	OREC, NR & Microsoft	Accenture	TBC

Developing a common approach across the offshore energy industry for collection, ingestion, sharing and storing of RAS data.

OLTER provides the benchmark for development and use of reliable, on-demand, standardised autonomous systems.

OLTER
NZTTP Programme

Dedicated Centre for Industrial Offshore Energy RAS

Key Outcomes

- Dedicated Centre for Industrial Offshore Energy RAS with 2 Technical Hubs (Data and Competency Hubs)
- Digital Marketplace (relating to payload sensor algorithms)
- Hi-Fidelity Digital Twin Environment to simulate and test new RAS vehicles
- Knowledge Portal

OLTER provides the benchmark for development and use of reliable, on-demand, standardised autonomous systems.


Energy Hub
NZTTP Programme

The Scottish Government
Riaghaltas na h-Alba

ETF Energy Hub

Energy Hub

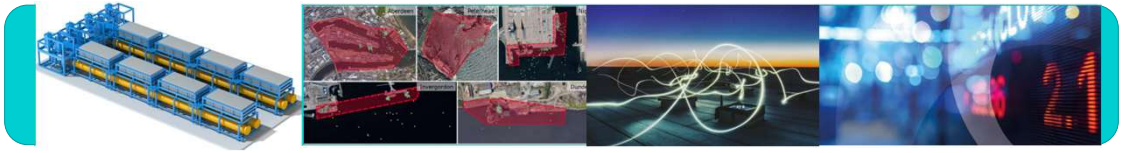
Energy hubs will utilise renewable sources, to produce green hydrogen and alternative fuels at scale.

The production, storage and transportation of zero carbon fuels play a key role in decarbonising heavy industry and are fundamental to the transition to net zero

Key Objectives

- Creating clean energy hubs across the UK will contribute towards new jobs and leverage existing skills and resources to power the energy transition.
- Understanding of the developing energy ecosphere – Where and when of the energy vectors
- Specific market challenges, opportunities and locations – Oil and Gas market decarbonisation – Marine fleet replacement fuels
- What do the future energy needs require investment in NOW to make the future ambition reality.

Energy Hub
NZTTP Programme



Phase 1 Deliverables

- Market segmentation analysis of the potential opportunities for alternative fuels across Scotland.
- Energy resources as vectors – What do we have, what is being developed- what do we need.
- Energy Hub full multi train concept development
- Suite of modelling tools to shape requirements and adjust and refine through life to support decision making
- investment case development

Phase 2 Deliverables

- Key enabling technology identification
- Pilot Studies.
- Early adopter fuel market identification – supply chain implementation
- Development of business case for strongest Energy Hub candidates
- Detailed Investment case to support creation of Scottish Energy Hub for Hydrogen Production

Energy Hub – Phase One - Landscaping

Energy Hubs
Phase One - Landscaping

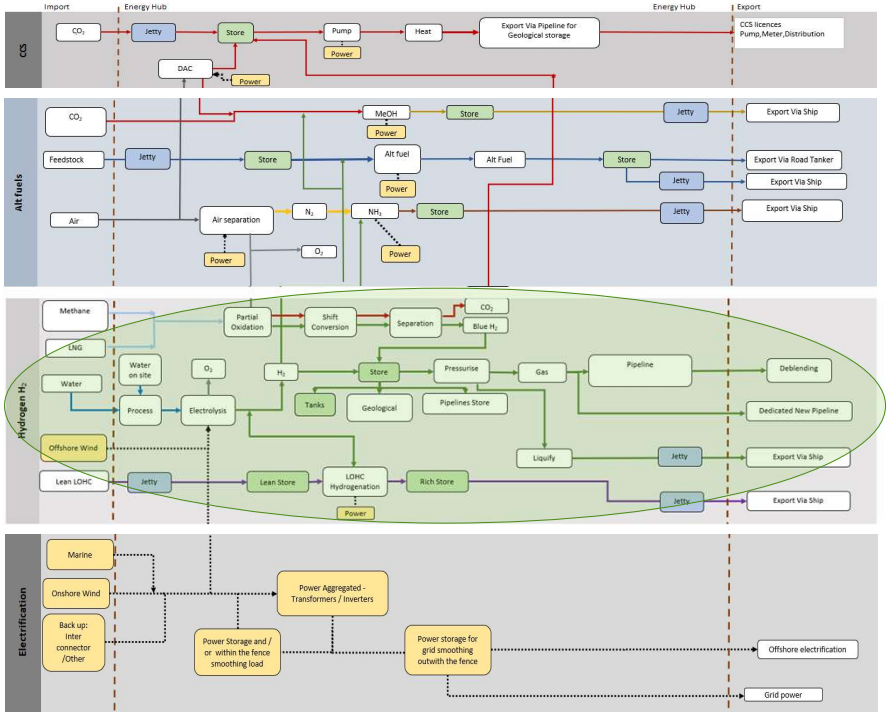
E-Fuel Market Segmentation

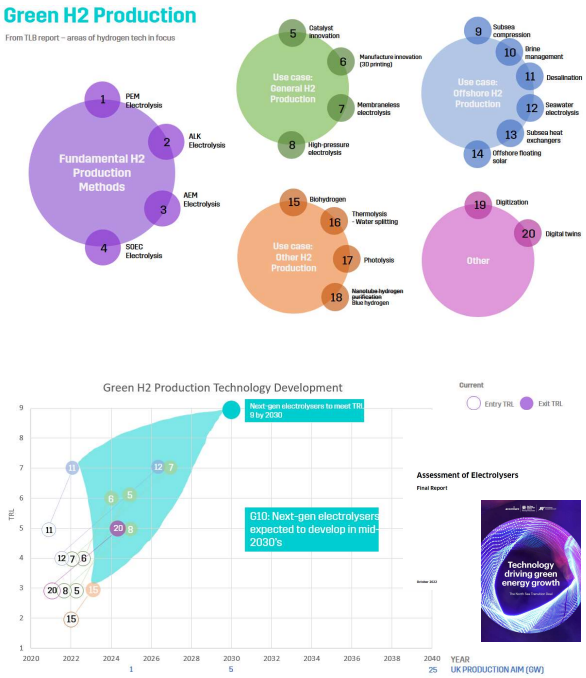
Energy Hubs Modelling

- **Energy Resource**
- **Oil and Gas E-Fuel**
- **Marine Infrastructure power management**
- **Domestic – Industrial Transportation**
- **Energy Hub Concept Development**
- **System Modelling**
- **Investor Case**
- **Economics Modelling**
- **Power System Management**

- **Energy Hub Production Storage**
- **Offshore Energy Hubs**
- **Micro Grids**
- **Energy Hub CCS**


• Increase market adoption
• Model Based System Engineering
Society
• Carbon incentive
• Technical Safety Standards for H2 operation
Regulatory
• Large Scale Commercial Electrolyser
• Storage
• Hydrogen Metering
Technology
• Adoption of Alt-Fuels inc H2 to develop markets
• Supply Chain development
Industry
• 1st iteration Standardised Energy Hub – Delivered
• GWh H2 production at Hub level
2030 Energy Hubs
• Nationwide integrated academic pathways
• Heating and insulation across legacy resolved
Society
• Dedicated renewable generation to Hydrogen production
• Support to Industry in transition
Regulatory
• Seawater Electrolysis
• Autonomous Robotics
• Next Generation Electrolysis – AEM – MLE- Thermolysis
Technology
• Sector wide Alt-fuel production
• Supply Chain development
• Low cost automation allowing cheap labour competition
Industry
• Full suite alt-fuels
• TWh production at National level
2040 Energy Hubs
• Industry 5.0 skillsets
• Skills Enabled Workforce
Society
• Carbon levelling worldwide
• Low carbon block chain for trading
• Carbon storage – liability resolved
Regulatory
• Hydrogen Subsea Compression
• Offshore Energy Hubs
Technology
• Nationwide Alt-fuel production
• Terrawatt export market
• Carbon import and storage
Industry
2050 Energy Hubs
• Industrial scale Hydrogen production on and offshore
• TWh at hub level





Phase Two of Energy Hubs-

Deliver R&D programmes developing technology required to deliver and operate an energy hub combined with prototype testing

Direction?

- Move away from Studies and into "doing stuff"
- Hydrogen
- Ammonia/E-Methanol

Technology

- PEM/ALK Electrolysers
- Desalination- Sea Water
- Storage

Delivery

- Concept FEED to FEED- preferred concept
- Scalable to TW/h H2 (timeframe?)
- Identify & pilot prototype technologies with largest potential in scale up

Hydrogen Backbone Link

NZTTP Programme


The Scottish
Government
Riaghaltas na h-Alba


Shetland
Islands
Council


eQ
enQuest


kellas
MIDSTREAM


Crown Estate
Scotland
Oighreachd a' Chrùin Alba


XODUS


Worley
energy | chemicals | resources


wood.

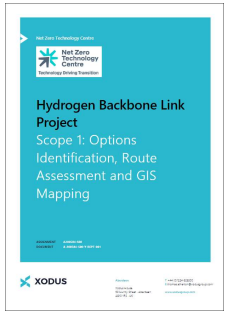

Wood
Mackenzie
A Verisk Business

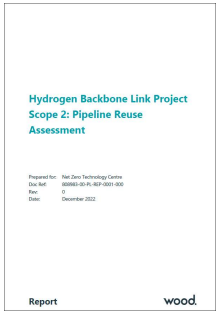

DNV·GL

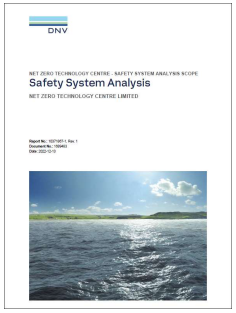

SGN
Your gas. Our network.

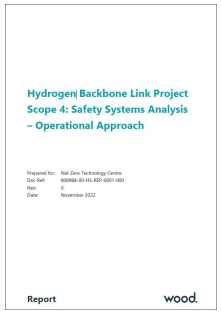

nationalgrid

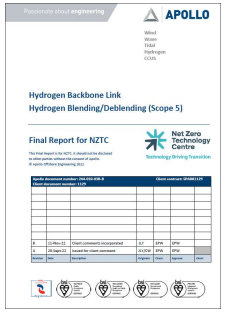
H2BL Reports

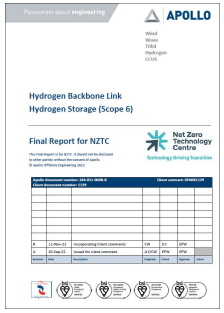


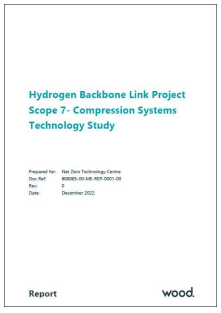


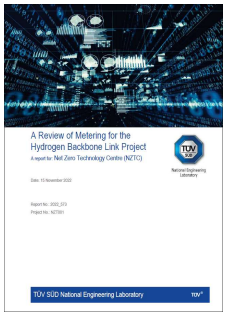


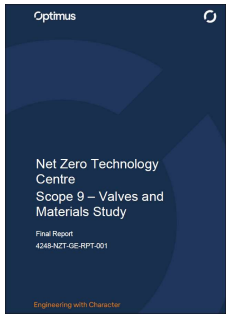


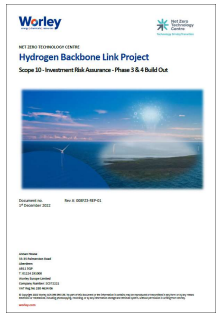


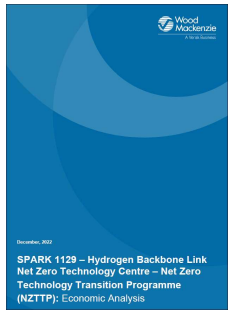


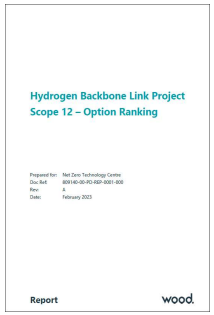




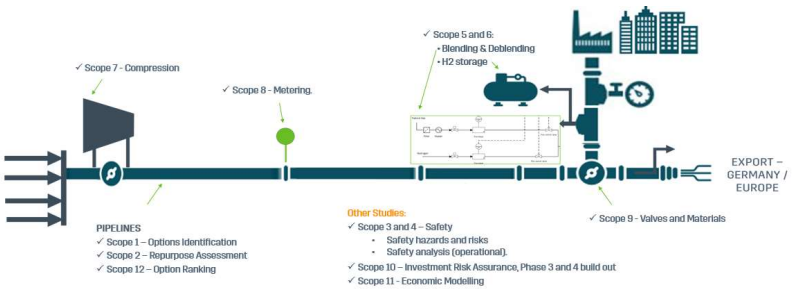


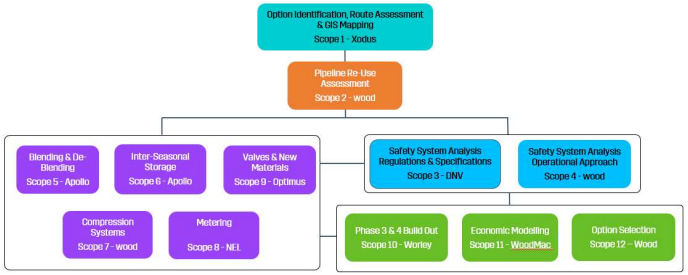






Hydrogen Backbone Link
NZTTP Programme





Scottish Government Riaghaltas na h-Alba gov.scot · kellas MIDSTREAM · Shell · EQ enQuest · Shetland Islands Council · Crown Estate Scotland Oighreachd a' Chrùin Alba · Wood Mackenzie A Verisk Business · XODUS · wood. · Worley · DNV·GL · SGN · nationalgrid

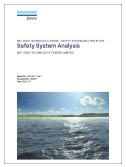
H2BL Report Summaries

Scope 1 – Options, Routes & GIS

- 2 new offshore pipelines options plus one part re-use case
- New pipelines assume 100% H2
- 2, 5 and 10GW sizing undertaken
- £2.7BN CAPEX for base case

Scope 2 – Pipeline Reuse

- Reuse assessment completed in line with ASME B31.12 following Prescriptive and Performance based methods
- SIRGE and CATS lines considered for reuse – both technically feasible in line with ASME code, Option A only.



Scope 3 – Safety Systems (Regulations)

- Specification and regulations for onshore pipes well understood
- Offshore regs & specs under development – H2PIPE
- Green Hydrogen at Scale group established to support understanding of safety aspects

Scope 4 – Safety Systems (Operational)

- Hydrogen poses additional risks when compared to natural gas across a number of operational safety areas
- Detonation, Detection & Embrittlement inspection tools needed

Scope 5 – Blending / De-blending

- Blending better understood – technologies all need scaled up
- De-blending needs more work – 2 technologies identified but not ready for commercial use

Scope 6 – Storage

- Technologies identified for interseasonal, operations and buffer storage
- Integrated approach needed here, interseasonal very location driven
- Subsea storage opportunity

Scope 7 – Compression

- Current centrifugal compressors have operational challenges e.g. blade tip speeds
- Reciprocating emerge as front runners despite cost & footprints
- Technology development opportunities

Scope 8 – Metering

- Existing designs are suitable, but repurposing is not recommended due to calibration challenges
- Different solutions for fiscal and non-fiscal operation. Requires H2 testing.

Scope 9 – Valves / New Materials

- No significant signs of incompatibility with existing designs / re-purposing, unless valve already showing integrity issues
- Potential hydrogen stress cracking on valve trim & wear on seals

Scope 10 – Investment Risk Assurance

- Six investment risk categories assessed including Social, economic, technical, market, timing and regulatory
- Partners highlighted key risk surrounding securing market for Scotland

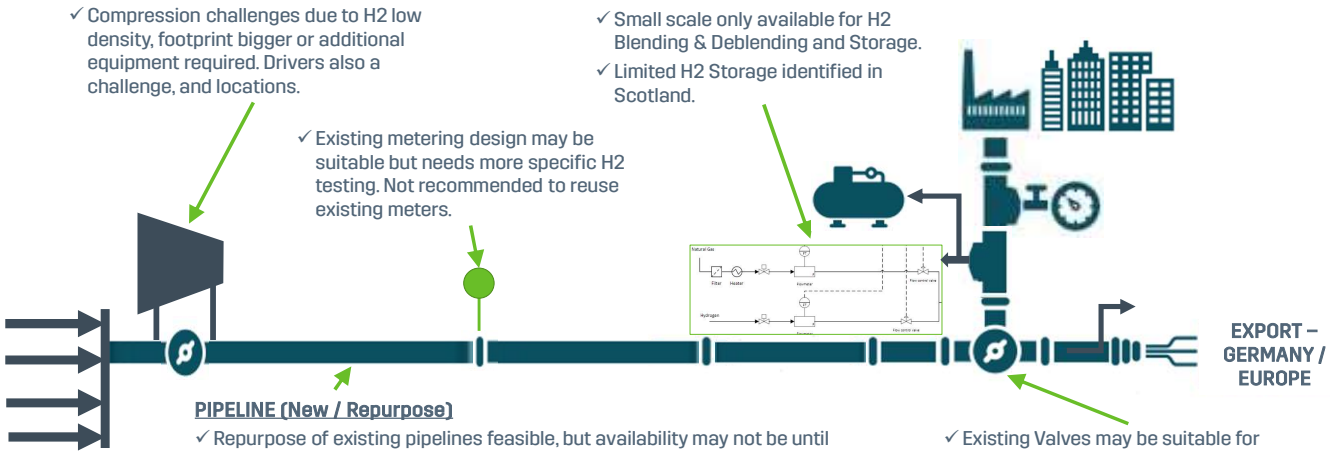
Scope 11 – Economics

- 10GW case, 6% IRR with 5 year build out results in implied tariff of £0.32/kg h2
- Sensitives for 4% and 8% IRR
- £0.32 tariff is significantly cheaper than other export vectors, providing cost competitiveness of Scottish H2.

Scope 12 – Option Ranking

- 6 ranking criteria used to assess the routes identified
- New pipeline case ranked highest (>20% difference to others)

Summary– Hydrogen Backbone Link



Other Findings

✓ Economic and Investment Assessment identifies business case and risks to be mitigated to enable a new pipeline.
✓ Safety hazards and risks associated understood, but legislation and risk management strategies still in development.
✓ Safety analysis (operational) still being developed.

Knowledge gaps

- Direct to Germany or joint with NTS (still requires new or reused offshore pipelines).
- Compression design, selection, operation and locations. Different for transport v distribution.
- Blending & de-blending and storage large scale and locations – including verification of users, supply and demand requirements and timeline.
- H2 Storage types and locations.
- Limited H2 specific Metering tests.
- Valve leakage rate acceptable or not – requires new design?
- Regulations and specs further checks.

Technology gaps

- Further studies on offshore network v onshore network, including operational philosophy and export layout
- Further studies on associated systems – close gaps
- Pilot tests – compression, blending & deblending, metering, valves.
- Continue Economic and Investment Case Analysis.

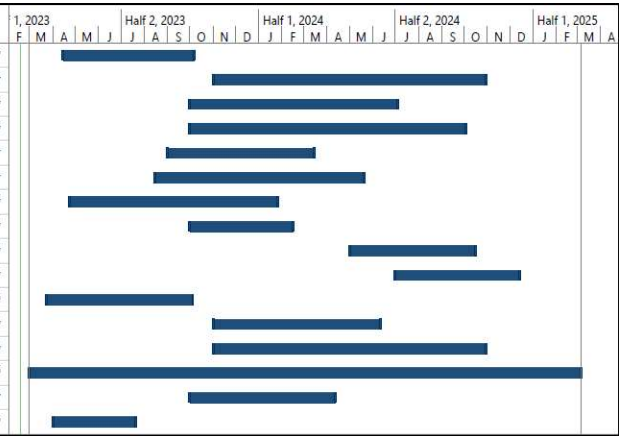
Phase 2 Potential Scope

Hydrogen Backbone Link
NZTTP Programme

SCOPE	DESCRIPTION	START DATE	DURATION	Overall Estimate
Scope 1	**Pipeline Decision Making** Study / Report on decision to continue with New Germany Case, including follow up from Optioneering Scope 12 done during Phase 1 **(internal or external?)**	Apr-23	6 Months	
Scope 2	**FEED** (New Pipeline or Offshore RoUK, depending on Scope 1 outcome) **Assumes pipeline only**	Q4 2023	7 - 12 Months	
Scope 3	**Pipeline reuse follow up** (depends on Scope 1)	Q4, 2023	6 to 9 Months	
Scope 4	**Existing Pipeline Qualification Testing** – (also depends on Scope 1 outcome) Will reduce costs and operational impact if off site spools are available for testing	Q4, 2023	9 to 12 Months (not full time)	
Scope 5	**Hydrogen Storage Requirements** including supply and demand users	Q4, 2023	6 Months	
Scope 6 (Optional)	**Compression selection and locations** dependant on other studies, Phase 2 requirements, Futuregird Feedback. (Some testing may be required)	Q3, 2023	9 months	
Scope 7	**Metering Testing and Optimisation Study** Requires Hydrogen Metering testing	Apr-23	9 Months	
Scope 8	**Valve Gaps close out**	Q4, 2023	4 Months	
Scope 9	**Risk Assurance**	Q2, 2024	5 Months	
Scope 10	**Economic Modelling and Cost Estimates**	Q3, 2024	5 Months	
Scope 11	**Irish Link to Backbone** May also include West Coast / Outer Hebrides	Mar-23	6 Months	
Scope 12	**Safety Studies - Regulations**	Q4, 2023	7 Months	
Scope 13	**Safety Studies - Operational (Technology Development)** Detonation, detection and inspection tools	Q4, 2023	12 months	
Scope 14	**Project Management** Various plus personnel - requires 1 to 2 Project Engs	March/April 2023	24 Months	
Variation	Early scope as part of Scope 6, to review storage requirement at SVT and Flotta, including reusing exiting pipelines	Apr-23	3 Months	
Scope 15 (Optional)	**Hydrogen Blending & Deblending Requirements** Dependant on pipeline operation (all new or RoUK)	Q4, 2023	6 Months	

Total Costs (without Scope 6 & 14)	£ 1,834,000
Total Costs (with Scope 6 & 14)	£ 1,939,000

ID	Task Name	Start	Finish
1	Scope 1 - Pipeline Decision Making	15/04/23	06/10/23
2	Scope 2 - FEED (New Pipeline or Offshore RoUK)	01/11/23	29/10/24
3	Scope 3 - Pipeline reuse follow up	01/10/23	04/07/24
4	Scope 4 - Existing Pipeline Qualification Testing	01/10/23	02/10/24
5	Scope 5 - Hydrogen Storage Requirements	01/09/23	14/03/24
6	Scope 6 - Compression selection & locations (Optional)	15/08/23	20/05/24
7	Scope 7 - Metering Testing and Optimisation Study	23/04/23	25/01/24
8	Scope 8 - Valve Gaps close out	01/10/23	15/02/24
9	Scope 9 - Risk Assurance	01/05/24	15/10/24
10	Scope 10 - Economic Modelling and Cost Estimates	01/07/24	13/12/24
11	Scope 11 - Irish Link to Backbone	23/03/23	04/10/23
12	Scope 12 - Safety Studies - Regulations	01/11/23	11/06/24
13	Scope 13 - Safety Studies - Operational (Technology Dev)	01/11/23	29/10/24
14	Scope 14 - Project Management	01/03/23	05/03/25
15	Scope 15 - Hydrogen Blending & Deblending (Optional)	01/10/23	11/04/24
16	Variation - Early scope as part of Scope 5	01/04/23	20/07/23



Alternative Fuel Gas Turbines

NZTTP Programme


SIEMENS
energy


Harbour
Energy


SERICAENERGY


eQ
enQuest


The Scottish
Government
Riaghaltas na h-Alba


XODUS


EQUANS


Worley
energy | chemicals | resources


METHANOL
INSTITUTE


Shell


PORT OF
ABERDEEN
EST.1136


oeUK


cnooc


BUMIARMADA

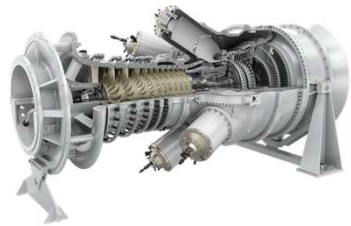
ETF Alternative Fuel Gas Turbines

Clean, remote power generation

Accelerating development of gas turbines capable of running on clean fuels.

Key Objectives

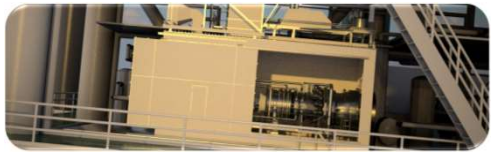
- Develop a zero-carbon fuel retrofit solution for aero-derivative gas turbines.
- Anchor Scotland's existing gas turbine supply chain in this new market – by performing the R&D and developing the technology and skills locally.
- Create and sustain Scottish jobs in the gas turbine repair and maintenance sector, through exporting the technology and skills to other sectors and countries.
- Stimulate growth in the local alternative fuel production market by creating new local demand.
- Extend field life and delay decommissioning of UKCS assets by improving operating efficiency.



Phase 1 Deliverables

- Compatibility Assessment & Online Calculator
- Option Identification
- Methanol Demonstrator test at RWG in Aberdeen
- Fuel studies – Methanol White paper, Optimised operation with Methanol, Ammonia & Hydrogen
- Case studies on a range of assets

Alternative Fuel Gas Turbines
NZTTP Programme



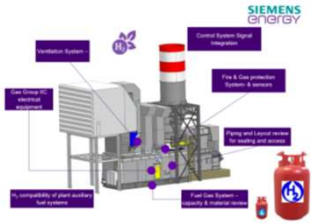
Phase 2 Deliverables

- Development of an alt fuel retrofit solution for offshore power gen.
- Tested and Verified at an Onshore Location.
- Identification of the offshore field trial candidate for phase 3
- Results Dissemination – share knowledge and understanding to change mindset

Fuel Studies

White paper on methanol - it's current & future place in the energy transition.

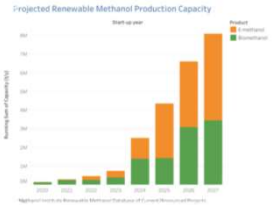
Engineering studies of Methanol, Ammonia, Hydrogen fuel for gas turbines



GT's account for up to 75% of UK offshore emissions

Methanol, hydrogen and ammonia are all technically feasible fuels with massive emissions benefits

Methanol is likely the most suitable for offshore implementation in the near term

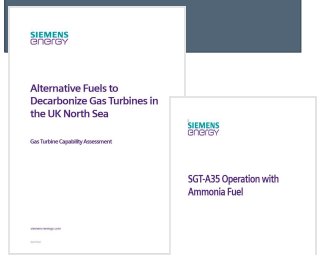


Publish the findings

Use the results to decide on the best fuel for specific applications

Influence the direction of the AFGT project

Help inform industry and government

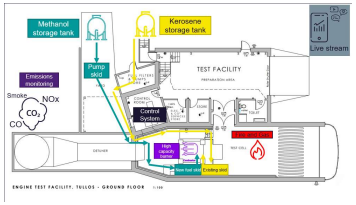


Methanol Demonstrator

Alternative Fuel Gas Turbines
NZTTP Programme

Full performance and emissions testing of an SGT-A20 on bio-methanol fuel

Modifications to turbine and fuel handling systems to enable methanol operation



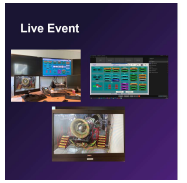
Test will take place in Aberdeen and will demonstrate:

CO2 reduction
NOx reduction
Smoke reduction
Performance improvement
Safe operation

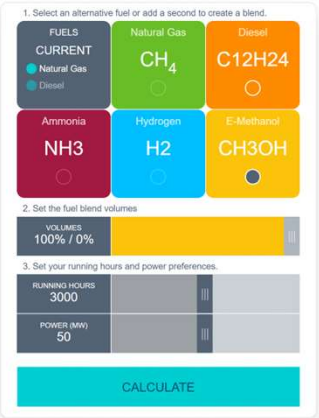
Demonstration test and live event happening in early 2023.

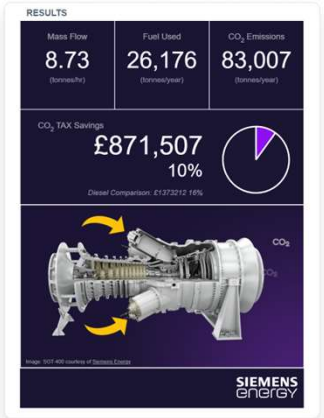
Real testing on an alternative fuel to prove the concept and real world benefits

Directly contributes to the Pilot Trial in Phase 2



Alt Fuel Calculator





Roll out on NZTC website for public use

Allow industry to see impact alternative fuel will have on their CO2 emissions

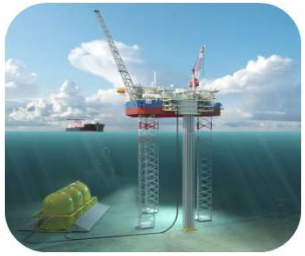
Case Studies

Alternative Fuel Gas Turbines
NZTTP Programme

Investigation into the requirements and feasibility into converting to Alt Fuel

Range of real onshore, floating and offshore assets

Supported by asset owners



Regulatory Issues, Challenges and Opportunities

Safety Case Implications

Plant & turbine modifications

Technology Gaps

Logistics and Storage

Use the detail study outputs to identify options for future phases

Anonymise key findings and publish into the public domain

Can use the understanding of technology gaps to influence direction of wider NZTC